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DARWINISM

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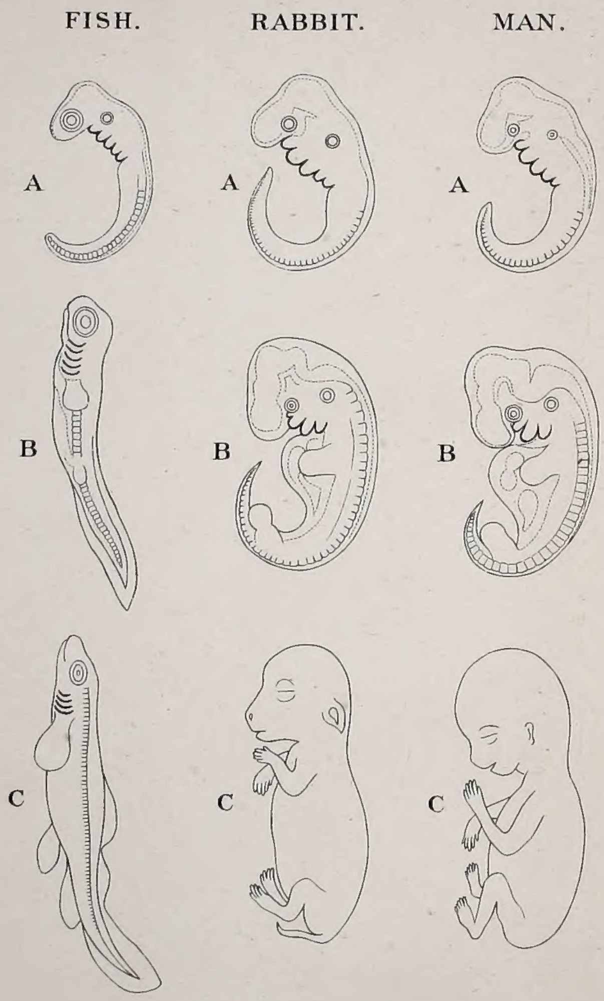

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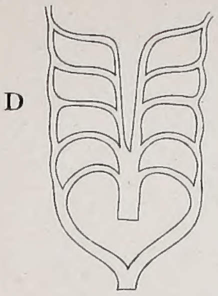

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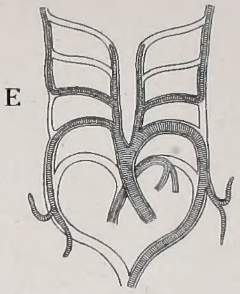

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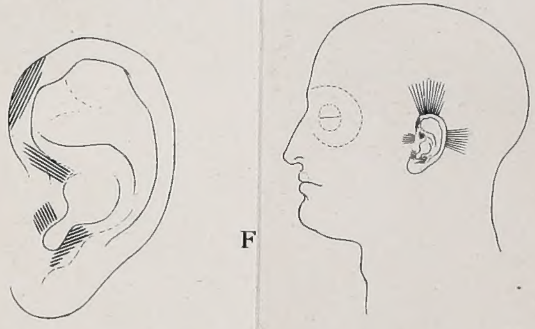


EXPLANATION OF PLATE.

The Figures marked **A** represent the corresponding stages of the development of the embryo of a fish, a rabbit, and a man. The gill-slits are drawn in thick lines

In all three instances the arteries supplying the gill-slits are after the pattern shown in Figure D.

The Figures marked **B** show a further stage in the evolution of the three animals. The gill-slits of the fish continue to be developed on the lines of a water-breathing apparatus; but the gill-slits of the rabbit and of the man are undergoing modification. Both of these embryoes, as well as that of the fish, have a movable tail.

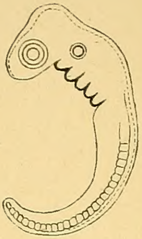
The Figures marked **C** show that, whereas the gill-slits are permanent in the water-breathing fish, they have disappeared, as altogether useless, in the rabbit and the man.

The Figure marked **E** shows, by the darker shading, the permanent arrangement of the arteries of a mammal. The lighter shading indicates the useless portions that are generally absorbed; but they sometimes remain as rudiments.

The Figures marked **F** show some of the muscles of the human ear, Those which are attached to the scalp, and which, in distant ancestors, moved the ear as a whole, forwards, backwards, or upwards, can be thrown into action by few people now living on the earth. Those muscles which are situated on the organ itself, and which formerly regulated its shape, are now absolutely powerless and useless.

FISH.

A



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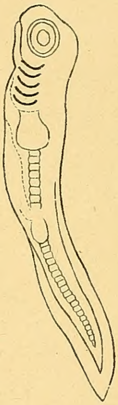

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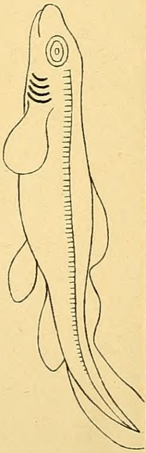

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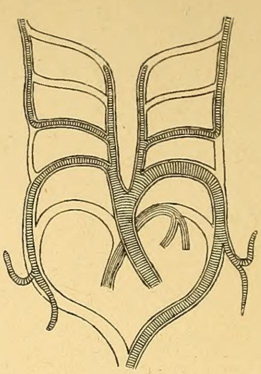

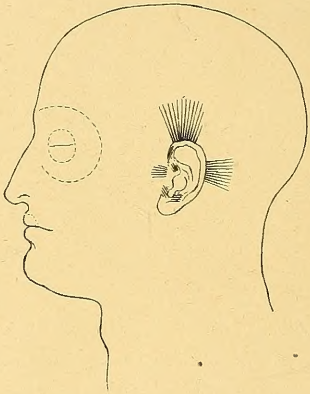

N OF PLATE.

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DARWINISM

AND THE

EVOLUTION OF MAN.

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H. C. MARCH, M.D., LOND.

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THE following Paper was written on the understanding, now general with theologians, that the Bible should be read for example of life and instruction of manners and is not to be regarded as the fountain of scientific truth. For those persons who think so, what follows may be helpful and suggestive; for those who think otherwise, it can hardly be useless or without interest. It consists of facts and thoughts gleaned from many writers:—Darwin, Spencer, Fiske, Mill, Lewes, Huxley, Dawkins, Dallas, Romanes, Clifford, Grant, Wallace, Croll, Haeckel; and it attempts to put the wide subject of Evolution in a clear and comprehensive form.

H. C. M.

INTRODUCTORY.

IN the early days of our race all natural phenomena were looked upon as *personal actions;* as the doings of gods, or of demons, or of the spirits of the dead. So that whenever it was desired to influence the course of events, and most men wish to do this, it became needful to take into account the inclinations of these powerful persons.

Hence arose what was called religion, which is from an Aryan root, "lag," to regard. It is the etymological opposite of the word "neglect," just as, in Latin, *religens* is the converse of *negligens.* And while *religens* means religious, *religiosus* means devoted. Religion, then, in a sense which includes every form of departed faith, had nothing *necessarily* to do with what we call morality, but referred to those observances—placatory, ceremonial, or sacrificial—that most nations have paid to the persons they worship.

It is clear that men, and especially members of a priesthood, who were pervaded with notions of this kind were not only unlikely to discover natural laws, but would be too ready to oppose any inquirers who, by gaining exact knowledge, had begun to see that old teachings were not always true.

So gathered the fateful conflict between Science and Religion. A strife of this sort must end in one of three ways.

1. Science may be crushed. This has been the end generally heretofore; as when Roger Bacon was cast into prison, while his writings were prohibited.

2. Or men may be compelled by logical necessity to believe the new learning, and may yet retain their old contradictory faith. Creeds that with very little modification have been taught for the last 15,000 years, have become hereditary, have entered into the material structure of the brain; and men shrink from the horror of uprooting them. But this inconsistency cannot be permanent: for as scientific proof grows ever more cogent, children are taught the old dogmas with less confidence, and the inherited tendency to believe them gets ever feebler.

3. Or, lastly, *religious teaching may change.* Let us illustrate these points by examples.

It was once an article of faith that our world was the steadfast centre of the universe. We still speak, without confusion, of the sun's rising and setting; but no one would now spontaneously say that "the sun rejoices as a strong man to run a race."

And when Galileo contended that the earth moves round a central sun, he was *crushed*, with an iron hand, and the church was triumphant. This is an example of the first of the three possibilities. That there might be no further mistake, and no more heresy in this matter, the Pope of the day promulgated a bull, which is in force to this hour, that the sun moves round the earth.

Then came Newton, who gave irresistible proof that Galileo was right and that the Pope was wrong. And because Newton could not be crushed, and because the infallible church was the most powerful organisation in Europe, the second of our three possibilities was established.

The College of Jesuits was always a learned body, and it includes men of the highest scientific attainments. Newton's "Principia" was presented to the Royal Society in 1686. An edition of this work was published by the Jesuits in 1739, and on an introductory page of the book is printed this humiliating declaration by PP. le Seur et Jacquier :—

Newtonus in hoc tertio Libro, Telluris motæ hypothesim assumit. Autoris Propositiones aliter explicari est poterant, nisi eâdem quoquè factâ hypothesi. Hinc alienam coacti sumus gerere personam. Cæterum latis a summis Pontificibus contrâ Telluris motum Decretis nos obsequi profitemur.

[In this book Newton hypothecates the earth's motion. The author's propositions could not otherwise be explained. Hence we are compelled to play another's part. But we profess our submission to the decrees made by the highest Pontiffs against the earth's motion.]

Thus we see that men driven to accept a fact as logically proved, may yet for some generations retain its direct contradictory as an article of religious faith.

Were we to say of these Reverend Fathers that, while they advanced a truth with the right hand, they held out a lie with the left, we should yield to an unworthy temptation.

It is wrong to throw stones; it were folly to do so when we live in a house built altogether of glass. Some of us were taught in youth that the earth was made in six terrestrial days; and may have been told when we doubted that we were on the road to perdition.

We have all advanced a long way on the road to perdition since then; or should have done so had there not come to pass the third possibility of which we spoke. *Religion is adapting itself to the requirements of Science.*

It has been discovered by modern theologians that in the sense of ancient writers "a day" means a great many millions of years;—that light, any more than colour, or fragrance, or music, which are all effects of matter in motion upon a sentient organism, could not have been created before the matter which moves and the organ which perceives;—that the fruit-trees of this planet were not perhaps, after all, made before the sun, moon, and stars;—that vegetable structures were not necessarily created before animals, because the reproduction of some plants depends upon the visits of insects, and because there are some organisms that are partly vegetable and partly animal;—that birds did not appear on the earth before reptiles, but after them;—and that Adam was not the first man; for, apart from the abundant and conclusive scientific proof of this fact, it is now remembered that Cain would hardly have been marked, "lest any finding him should kill him," had there been only one other man upon earth, and that man Cain's own father.

But if the Hebrews traced their descent to some semi-divine and not very remote ancestors, so likewise did other races.

All the founders of the Saxon Kingdoms of this country claimed descent from Bældæg, who was the son of Woden, the father of the gods, and the creator of the world. Thus there are eight genealogies in the Saxon Chronicles such as this:—Cerdic, who landed in England from five ships, was the son of Elesa, Elesa of Esla, Esla of Giwis, Giwis of Wig, Wig of Freawine, Freawine of Frithugar, Frithugar of Brond, Brond of Bældæg, Bældæg of Woden.

Later, however, after England was converted to Christianity, it was taught that Woden, no longer a god, was himself descended, as shown by a full genealogical tree, from Sceaf, who was the son of Noah, and who, for obvious convenience, was said to have been born in the ark.

And now that we have been driven to admit that neither Adam nor Bældæg was the first of our race, Darwin stands forth, and claims from us the belief that man, instead of having fallen from a pristine state of bodily, intellectual, and moral perfection, has been slowly and painfully evolved from some lowly ancestral form, the common parent of all vertebrates, by the prolonged action of surrounding forces or laws, the chief of which is the law of Natural Selection.

Is this doctrine true? Can it be proved? Must we believe it?

Truth—evidence—belief; what are these?

Truth is the exact correspondence between the subjective order of our conceptions and the objective order of the relations among things—between thoughts and facts. Truth is a correct interpretation of the causes of our sensations; a harmony between our ideas and the surrounding coexistences and successions that occasion these ideas.

Belief is the *recognition* of something as a reality in Nature.

Evidence is the antecedent of which belief is the consequent.

Proof is such evidence as compels belief.

Belief on evidence is always a case of the generalising process; the making an induction, the drawing an inference.

The generalising propensity, in a mind not disciplined by thought, nor as yet warned by its own failures, outruns the evidence—or, rather, precedes any conscious consideration of evidence. Such consideration, indeed, has for its function to limit our spontaneous impulse of generalisation, and to restrain within just bounds our expectation that the unknown will resemble the known.

When we are directly conscious of a thing, the evidence and the belief are one and the same thing.

In all other cases, belief is grounded on the constancy of the course of Nature; it is based on the universal postulate of the persistence of force.

Whatever it is that we believe, the justification of the belief must be, that unless it were true the uniformity of the course of nature would not be maintained.

It is not meant by uniformity that Nature has never known cataclysms or convulsions. The submergence of a continent, the outburst of molten lava, the terrible break-up of a glacial period, take place in a strict conformity to law. The ascent of a balloon is in accordance with the same law of gravitation which governs the earth's orbit and occasions the fall of a stone.

DARWINISM.

AND now what is Darwinism? It shall be told in the words of the master himself.

"If, under changing conditions of life, organic beings present "individual differences in almost every part of their structure, and "this cannot be disputed; if there be, owing to their geometrical "rate of increase, a severe struggle for life at some age, season, or "year, and this certainly cannot be disputed; then, considering "the infinite complexity of the relations of *all organic beings* to "each other and to their conditions of life, causing an infinite "diversity in structure, constitution, and habits *to be advantageous* "*to them*, it would be a most extraordinary fact if no variations "had ever occurred useful to each being's own welfare, in the same "manner as so many variations have occurred that have been "useful to man.

"But if variations useful to any organic being ever do occur, "assuredly individuals thus characterised will have the best "chance of being preserved in the struggle for life; and from the "strong principle of inheritance, these will tend to produce "offspring similarly characterised.

"This principle of preservation, or the survival of the fittest, I "have called Natural Selection.

"It leads to an improvement of each creature in *relation to its* "*organic and inorganic conditions of life;* and consequently, in "most cases, [though by no means in all] it leads to what must "be regarded as an advance in organisation. Nevertheless low "and simple forms will long endure if well fitted for their simple "conditions of life.

"Natural selection, on the principle of qualities being inherited "at corresponding ages, can modify the egg, seed, or young, as "easily as the adult.

"Amongst many animals, sexual selection will have given its aid "to ordinary selection, by assuring to the most vigorous and best "adapted males the greatest number of offspring.

"Sexual selection will also give characters useful to the males "alone, in their struggles or rivalry with other males; and these "characters will be transmitted to one sex or to both sexes "according to the form of inheritance which prevails."

This, then, and nothing else, is Darwinism.

"The thoughtless remark," says Prof. Fiske, "is sometimes "heard, that the Darwinian theory rests upon purely gratuitous "assumptions and can never be submitted to verification. On the "contrary, the theory of natural selection, when analysed, will be "found to consist of eleven propositions, of which nine are "demonstrated truths, the tenth is a corollary from its nine "predecessors, and the eleventh is a perfectly legitimate postulate."

Let us enumerate these propositions :—

1. More organisms perish than survive.

2. No two individuals are exactly alike.

3. Individual peculiarities are transmissible to offspring.

4. Individuals whose peculiarities bring them into closest adaptation with their environment are those which survive and transmit their peculiar organisations.

5. The survival of the fittest thus tends to maintain an equilibrium between organisms and their environments.

6. But the environment of every group of organisms is steadily, though slowly, changing.

7. Every group of organisms must accordingly change in average character, under penalty of extinction.

8. Changes due to individual variations are complicated by the law that a change set up in any one part of a highly complex and coherent aggregate, like an organism, initiates changes in other parts.

9. They are further complicated by the law that structures are nourished in proportion to their use.

10. From the foregoing nine propositions, each one of which is indisputably true, it is an inevitable corollary that changes thus set up and complicated must eventually alter the specific character of any given group of organisms.

11. It is postulated, that, since the first appearance of life upon the earth's surface, sufficient time has elapsed to have enabled such causes as the foregoing to produce all the specific heterogeneity now witnessed.

As this is a very condensed and somewhat technical, though a most cogent and logically constructed syllogism, it may be well to give a few illustrations or explanations of each of the propositions.

An organism is any living thing, or any independent aggregation of living stuff, that possesses a visible structure. In some cases the only structure that an organism can be said to possess is *a surface* and *an interior*.

Life is the continuous adjustment of the internal relations of an organism to its environment or surroundings.

That portion of the organism by which this adjustment is wrought, consists in all cases of protoplasm.

From the oxidation of this substance and from its concomitant re-integration or restoration by the taking-in of new matter, result the phenomena which we term vital.

These phenomena are growth and reproduction; and reproduction is a form of growth.

1. More organisms perish than survive.

It is hardly needful to insist upon this with respect to the vegetable world, though Linnæus has calculated that if an annual plant produced only two seeds (and there is no plant so unproductive as this; they are often prodigiously prolific) and their seedlings next year produced two, and so on; then in 20 years there would be a million plants.

As regards animals, the elephant is reckoned the slowest breeder of all. Assuming that it begins breeding when thirty years of age, and goes on breeding till ninety years old, bringing forth six young in the interval, and surviving till one hundred years old; then after a period of about 750 years there would be nineteen million elephants alive, descended from the first pair.

Slow-breeding man has doubled in twenty-five years; and at this rate in less than a thousand years there would literally not be standing-room for his progeny on the face of the earth.

A viviparous fish, such as the Blenny, brings forth between 200 and 300 young every season, all alive and playing round the parent together.

Of the oviparous fish, the Herring will yield 10,000 eggs; the Mackerel 500,000; the Flounder over 1,000,000; while the Cod spawns annually 9,000,000 of eggs.

It should be remarked, as explaining great differences of fecundity, that they follow the law that, on the one hand, complexity of organisation is hindered by reproductive activity, and that, on the other hand, when a higher degree of organisation is reached, reproduction goes on less vigorously.

It is clear, however, that more organisms perish than survive.

2. It is equally clear that no two individuals are exactly alike. On the contrary, the differences in the offspring of the same parent are often well marked.

Robert Dick, who was opposed to the Darwinian doctrine, writing on wild roses, says, "Take the *rosa spinosissima*, or "thorny rose; how very unlike the common dog-rose, *rosa* "*canina*, it is. Would you believe that one bush of it on the "boulder clay here (Thurso) has put forth flowers hardly dis-"tinguishable from dog-roses; the leaves large, the flowers white, "the prickles hooked, and so on. Some stocks of *rosa* "*spinosissima* have pink petals; in dry years red petals and "excessively hairy leaves; in wet seasons white petals and smooth "leaves; in fact, the leaves of the whole plant vary from an eighth "of an inch to more than an inch in length. *All the roses* "growing wild in Caithness may have *come from one stock*, but "from what particular stock I cannot tell."

As regards animals, a careful series of observations has lately been made in America, with the result of ascertaining that in wild individuals the amount of *measurable* variation—length, circumference, weight—is to the extent of between 10 per cent. and 20 per cent. of the average dimensions.

3. Individual peculiarities are transmissible to offspring. As witness to the truth of this proposition, we may refer to all gardeners, pigeon fanciers, and breeders of cattle. All the homes in England present family likenesses, and inherited mental endowments and moral traits. A mare crossed with a quagga has a striped foal. It is well known that some diseases are hereditary; and rabbits in whom epilepsy has been artificially induced, have epileptic progeny.

4. Individuals whose peculiarities bring them into closest adaptation with their environment are those which survive and transmit their peculiar organisations. One's environment is the circumstances in which one is placed. Friends, foes, food, climate, temperature, and the constitution of the atmosphere; all things that can act upon us, and upon which we can re-act, form our environment. Plants that can best protect themselves from the depredations of insects, will outlive others. The swallow, strong in flight, will reach the promised land, when weak ones perish in the wilderness. In every migration the feeble flyers are weeded out, and the strong survive and multiply. In a close commercial competition, men with clear heads and sober habits, with untiring energies and enduring frames, are more closely than others adapted to their environment, will win in life's race, will survive and transmit their peculiar organisations.

5. The survival of the fittest thus tends to maintain an equilibrium between organisms and their environments. No two cubs of a polar bear are covered with exactly the same quantity of fur. If the fur of one of them is insufficient to protect him from the arctic cold, he will perish. If the fur of another is so thick as to hinder his hunting for food, he will be at a disadvantage. The fittest to survive will be in equilibrium with his environment.

6. But the environment of every group of organisms is steadily, though slowly, changing. The intensity of the sun's heat varies. Local temperature is affected by the precession of the equinoxes. Periodic changes take place in the shape of the earth's orbit. Glacial epochs come and go. The surface of the earth rises and falls. Islands are joined into continents; and continents are broken up into islands. Food is plentiful or disappears in a

famine. Warlike foes burst into peaceful lands. Conquest paralyses commerce, and inventions revolutionise trade.

7. Every group of organisms must accordingly change in average character, under penalty of extinction. An organism not in equilibrium with its environment must perish.

The crust of the earth is crowded with the remains of extinct plants and animals. Species, and genera, and orders; all extinguished, and by what? The mammoth and the rhinoceros, the sabre-toothed tiger and the lion that in former days haunted the valley of the Thames, why have they left no descendants? From failure of food, from change of climate, from mutual slaughter, from the hand of man? Be the cause what it may, they failed to adapt themselves to an altered environment, and they perished.

Some existing marine animals, like the lingula and the terebratula, of lowly types, seem to have varied very little even during an enormous lapse of time. As the fossils which represent the ancestors of these molluscs consist only of their shell-forms, as the animals themselves have in all instances absolutely vanished, and as the shell is but a feeble index to the structure of its contents, we can only infer from analogy that some degree of evolution has taken place.

All that the proposition states is that organisms must be in equilibrium with their environment. If the environment is constant, so must be the organism, when an equilibrium has been once attained. Now, marine changes are chiefly those of temperature and depth, and as these vary with extreme slowness, all that would be necessary on the part of the bivalves in question, in order to adjust themselves to external conditions, would be to shift their position, a little to the north or a little to the south, as their case might require.* There is one structural adjustment, however, which even molluscs must make on pain of extinction.

Water, marine or fluviatile, contains in solution a varying quantity of carbonic acid, which has a destructive action on those shells that are made of carbonate of lime.

Hence the shell of molluscs is covered with a layer of animal matter, called an epidermis. It is of a horny consistence, and, serving to protect the shell from the action of carbonic acid, is of greater or less thickness according to the quantity of acid dissolved in the surrounding medium. In fresh water this quantity is often very large, and it is on fresh-water shells that the epidermis attains its greatest thickness. In some localities, where the animal has failed to adjust itself to the environment, and the epidermis is insufficiently thick, the substance of the shells is found deeply corroded.†

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* The existing Lingulæ are found only in southern seas; the existing Terebratulæ only in very deep water.

† The valves of the existing Lingulæ are of a very horny texture.

It should not be forgotten, however, that to become adapted to changing circumstances, some organisms must undergo what has been called "degradation." Loss of size, loss of organs, even loss of intelligence, may be the result of this adaptation.

Smallness is beneficial when the supply of food is strictly limited, as on an island; and insular animals are often diminutive, like the Shetland pony and the extinct pigmy elephant of Malta. Smallness is also of service to creatures that burrow, and they are always less than allied species that live on the surface of the earth. It is obviously advantageous to an animal to be without organs for which it has no further need; and, though they are slow in disappearing, they may at length vanish altogether.

That an organism should gain by the loss of intelligence it is more difficult to understand, because we are accustomed to invert nature's pyramid, to set a higher value on mental activity than on physical well-being, to think more of the flower than of the root. Suppose the case of a primitive tribe of hunters, skilled in tracking their prey, who should begin to train dogs for the chase. Suppose the hounds' excellence in bringing home a quarry, associated with their original pleasure in predatory pursuit, to have become hereditary. The men of the tribe need less skill as hunters and less as trainers. Now, skill, which is a form of intelligence, is a stored-up energy, acquired, and in some degree maintained, by an expenditure of force. If an economy of force were physically advantageous in the social condition supposed, such a loss of intelligence would be an indirect gain.

Rufescent ants are a slave-making species. The slaves of *Polyergus rufescens* have learnt their duty so well and practise it with so much pleasure and assiduity that their masters have lost the greater part of their instincts. They have ceased to build, they take no care of their young, they do no manner of work, and they cannot even feed themselves.

As regards our own race, an undue fostering of those who are too ready to receive help is a recognised cause of pauperism and imbecility; and a lapse of men into savagery takes place when muscular strength and a brutal nature become, for any reason, of more service than culture and skill. So strange are the ways by which an organism adapts itself to its environment, though not always with final success; for it is probable in the case of the degraded man, and perhaps certain in that of the degraded ant, that we are spectators of a slowly closing scene, and that both races are about to become extinct.

We have seen that wild animals vary to the great extent of 10 or 20 per cent. of their average dimensions. At present, however, external conditions are changing very slowly; so that these individuals derive no benefit from their variation, and are not better, but may be worse, fitted to survive than the rest.

But if the environment changed more suddenly, varied individuals would be found ready to take advantage of it.

"Consider the glacial epoch of 260,000 years, beginning about "980,000 years ago. During that long period," says Mr. Croll, "the changes from cold to warm conditions of climate every "10,000 or 12,000 years must have been of the most extreme "kind. Compare that with the period beginning, say, 80,000 "years ago, and extending to nearly 150,000 years into the future, "during which there will be no extreme variations of climate, and "how great is the contrast! How extensive the changes in "species must have been during the first period, as compared "with those that are likely to take place during the latter."

In this argument Mr. Croll confines his view to the influence of climate, which is, indeed, but a part of an animal's environment. The most important portion of the present circumstances of mankind is undoubtedly the keenness of the mutual struggle for existence.

8. The eighth proposition is that changes due to individual variation are complicated by a law that a change set up in any one part of an organism initiates changes in other parts. This phenomenon is generally spoken of as "*correlated variation.*"

Proof is afforded even by the conditions of ordinary growth. It is a fact in physics that in similarly shaped bodies the masses vary as the *cubes* of the dimensions, whereas the strengths vary as the *squares* of the dimensions.

"Supposing," remarks Mr. Spencer, "that a creature which a "year ago was one foot high, has now become two feet, while it "is unchanged in proportions and structure, what are the necessary "concomitant changes that have taken place in it? It is *eight* "*times as heavy;* that is to say, it has to resist eight times the "strain which gravitation puts on its structure; and in producing, "as well as arresting, every one of its movements, it has to overcome eight times the inertia. Meanwhile, the muscles and bones "have severally increased their contractile and resisting powers in "proportion to the areas of their transverse sections, and hence "are severally but *four times* as strong as they were. So, while "the creature has doubled in height, and while its *ability* to "overcome force has *quadrupled*, the forces it *has* to overcome "have grown *eight times as great.*"

Further, in order that an animal may have some structure specially and largely developed, it is indispensable that several other parts be modified and co-adapted.

That the elk's enormous antlers may grow, they require an increased blood supply. The arteries of the skull must therefore enlarge, and the balance of the circulation must be readjusted. As the head becomes heavier, by 60 pounds, with the added weight of the horns, more powerful muscles and ligaments are needed for its support; and these, in turn, must be furnished not only with more blood but with an augmented nerve-force, while the bony ridges to which the muscles are attached must grow stronger and more prominent.

Now, on the one hand, if the total quantity of the blood and nerve-force of the body remains the same, some organs must be supplied at the expense of others.

On the other hand, if the total quantity of blood is increased, more food must be taken, the digestive functions must rise in activity, and, as actually occurs during the gestation or pregnancy of mammals, the heart which drives the increased quantity of blood must itself grow larger and more powerful.

But with a larger and more powerful heart, and with an increased quantity of blood, other organs will be stimulated; and so waves of change, correlated coincident variations, pervade the entire system in every conceivable combination.

The operation of the same law is seen in plants. In composites, the flowers of the circumference, partly as the result of their position, have their corollas much more developed than those of the centre; and sometimes the seeds of the circumference differ greatly from those of the centre, while occasionally the reproductive organs of the circumferential flowers are quite abortive.

9. The ninth proposition is that structures are nourished in proportion to their use. Witness the blacksmith's arm, and the udders of cows that are habitually milked. Darwin found that in the domestic duck the bones of the wing weigh less, and the bones of the leg more, in proportion to the whole skeleton, than do the same bones in the wild-duck; a difference to be attributed to the domestic duck flying much less and walking more than its wild parents.

The effects of *disuse* are shown in the eye of moles, and of a few burrowing rodents, which, in some cases, is of minute size, and in other cases is quite covered by skin and fur. In certain cave-crabs, too, *the stalk* for the eye remains, though the eye is gone.

Parasites present further examples. Some of the *Hippoboscidæ*, especially those that infest birds like lice, have a pair of slender wings, but from long-continued inaction they are powerless for flight; the four wings possessed by the ancestors of the flea are now represented by as many minute scales; and there are some intestinal worms that have no organs left except those that are necessary for growth and reproduction.

From the foregoing nine propositions, continues Prof. Fiske, each one of which is indisputably true, it is an inevitable corollary that changes thus set up, and complicated, must eventually alter the specific character of any given group of organisms. In other words, it follows that the descendants of some common ancestor may, must, and do undergo such correlated variations as to become at last mutually infertile.

And here comes up the interesting subject of the sterility of hybrids, and we may give it a brief consideration, though it has no direct bearing on Darwinism or Evolution.

Complete sterility is termed Agenesis, and complete fertility, Eugenesis. Examples of Eugenesic crossings, as given by Broca, are those between dogs and wolves, goats and sheep, camels and dromedaries, hares and rabbits.

But within the extremes of sterility and fertility are the two conditions of Dysgenesis, as between the horse and the ass, where mules are sterile; and Paragenesis, as between Negroes and Teutonic Europeans, where mongrels of the first generation have only a partial fecundity, though they breed more readily with the parent species. Similarly, in plants, the hybrids of *intermediate types between the two parent stocks* are sterile, while those resembling one or the other species are prolific.

Let us consider the problem in terms of force. Force is whatever moves matter, or tends to move it. In the first case we have motion; in the second case we have tension. Accordingly, the so-called vital forces, or the forces which an organism derives from its food, may produce either motion or tension. There are two forms of motion: molar, the motion of masses; and molecular, the motion of atoms. While the first form consists chiefly of locomotion, or movement from place to place, the second form consists chiefly of vibration, which is movement in one place.

As a plant grows we see matter in motion. Within limits, the more food a plant has the more it grows; the more stems and the more leaves it puts forth. It is well known that flowers, which are the reproductive organs of plants, are leaves without stems. The sepals, petals, stamens, and pistils are all the homologues of leaves, and these, without internodes, or intermediate stems, are arranged in whorls or spirals. Flowering, then, is, in a sense, the opposite of growth. Instead of there being a long internode between each floral element, these elements are all crowded down together, and the energies of the plant are expended, not in motion, but in tension.

Now, molecular agitations have a numerical period, and vibrations of like periods reinforce one another. Hence the molecular agitations of the ovule are able to be reinforced by those of the pollen *of the same species*, because they are both of the same numerical period of vibrations.

In some lowly organisms, the union of two elements is unnecessary to reproduction; but as evolution advances, as the structure to be ultimately built up becomes more and more complex, reinforcement is required. When the tensional energies of the ovule are reinforced by the tensional energies of the pollen, a seed is produced. Now there is nothing more certain than this, that a seed contains vast forces in a state of tension. Supply the seed with warmth and moisture, and these forces are liberated, and reproduction completes itself.

We witness the same series of events in animals. When the body has ceased to grow, but when the quantity of food taken and assimilated continues to be much the same as before, the force produced, unable to expend itself in growth, enters a state of tension, becomes latent, potential, and results in the reproduction of the species.

Having grasped this idea, let us, in order to understand the reason of the sterility of hybrids, take a very simple illustration. Let us suppose the period of the tensional molecular vibrations of the horse to be 20 ; and, as a matter of course, let us suppose that the period of the molecular vibrations of the mare is also 20. These periods will reinforce one another, and fertility results. Now let 19 be the molecular period of the ass; 19 and 19 will also reinforce one another. But in the case of a mule, when the ass is crossed by the horse, we have molecular periods of 19 and 20, which not only will not fully reinforce one another, but will occasion some amount of what is called "interference," which may be more or less according to circumstances. And the result is that the tensional molecular vibrations of the mule having suffered interference, they are no longer able to reinforce one another, and the hybrid is sterile. The total sterility between some animals would in like manner be due to the fact that their molecular periodicities, say 7 to 131, are such as afford each other no reinforcement whatever. On the other hand, in "breeding in and in," as consanguineous crossing is called, the molecular periodicities are so exactly alike that even special tendencies, like a tendency to disease, are reinforced; while in exsanguineous crossings there is sufficient "interference" in the molecular periodicities to make such tendencies *cancel out.*

At length we have reached Prof. Fiske's last proposition, which is the postulate that since the first appearance of life upon the earth's surface, *sufficient time* has elapsed to have enabled such causes as the foregoing to produce all the specific heterogeneity now witnessed. The time which has elapsed we have no means as yet of accurately measuring. Perhaps our best index is a consideration of the formation and destruction of stratified rocks, of deposition and denudation.

Shells of dead animals have lain for long on the ocean's floor before they were embedded in sediment. Fossil oysters in clay are found with serpulæ, barnacles, or corals attached to the *inside* of the valves. Often, too, the creatures that have attached themselves to the empty shell of a mollusc have not only grown to maturity before the shell was covered with deposited matter, but have, in their turn died, and their hard coverings have been slowly pierced by other creatures, while yet the deposit had not covered the mollusc to half its thickness. Not less slow is denudation. In "faults," when one side of a dislocation has been raised perhaps thousands of feet above the other, and both have been washed down to a level again, though it can be known how much more has been denuded on one side than on the other to restore the level, it cannot be known how much has also been taken from both sides. A fault crossing from Dunbar to the Ayrshire coast, amounts to nearly three miles vertical. This dislocation has on the south side the ancient silurian rocks on which rest the carboniferous. On the north, between the carboniferous and the silurian occurs the old red sandstone. So that the dislocation is older than the carboniferous era. For originally the silurian rocks, south of the fault, must have been covered by the prolongation of the old red sandstone, afterwards completely removed by denudation. Thus the enormous thickness of three miles of old red sandstone must have been denuded away during the period which intervened between its deposition and the subsequent accumulation of the carboniferous limestone and coal-measures now lying directly upon the silurian rocks. The quantity of sediment brought down by the Mississippi has been carefully investigated by order of the United States Government, The result is that the mean level of its enormous area of drainage must be lowered $\frac{1}{4566}$th of a foot annually, or one foot in 4566 years. Mr. Croll, Mr. Geikie, and Sir Charles Lyell consider that denudation takes place at the rate of one foot in 6000 years. Take double this rate, and at two feet in 6000 years the time occupied in denuding three miles of old red sandstone would be 45 millions of years, and this takes no account of the time occupied in deposition.

But *older* than the old red sandstones, and before they were deposited, the silurian formations had been denuded to depths of thousands of feet, and these ancient formations were themselves deposited in the ocean by the slow denudation of the Cambrian rocks. These, in turn, had been formed from the earlier Laurentian strata; and the Laurentian rocks themselves were built up from the ruins of other rocks, which were themselves sedimentary rocks, and not the primary rocks of the globe. On the other hand, above the carboniferous, come the Permian, Triassic, Oolitic, Cretaceous, Tertiary, and recent rocks; the whole amounting in thickness to nearly 14 miles of British strata. Surely then, "sufficiency of time" is less a postulate than a demonstrable fact; and we are at last fully entitled to claim that the truth of Darwinism is abundantly proved. In other words, *the evidence in its favour compels belief.*

But there are two classes of persons whom no amount of evidence will convince. Those who are deeply pledged and committed to ancient creeds; and those who are so deficient in the logical faculty as to be unable to see the cogency of an argument. To the first class belonged the courageous priest, now no more, who retorted upon a troublesome geologist, that when God made the rocks he made the fossils in them. To the second class belong men like Parallax and his followers, who still maintain that the earth is flat, and that the sun and stars circle round her.

FURTHER PROOF OF DARWINISM.

SHOULD more evidence of the truth of Darwinism be required, it may be obtained almost without limit. Let us run over the proofs furnished by 1.—Subordination. 2.—Palæontology. 3.—Homology. 4.—Rudiments. And 5.—Embryology.

1. *As to subordination* or classification: "It is a truly wonderful "fact," says Darwin, "the wonder of which we are apt to overlook "from familiarity, that all animals and all plants, throughout all "time and space, should be related to each other in groups "subordinate to groups. The varieties of one species; the species "of one genus, with its sections and subgenera; and genera "related in different degrees, forming the sub-families, families, "orders, sub-classes, and classes, of the so-called Natural System." Now the element of *descent* has been universally used in ranking together the sexes, ages, dimorphic forms, and acknowledged varieties of the *same species*, however much they may differ from each other in structure. This element of descent is *the one certainly known cause of similarity in organic beings.* Darwinism, then, is the extension of this element of descent,—descent with modification—to cover the whole of the Natural System of classification.

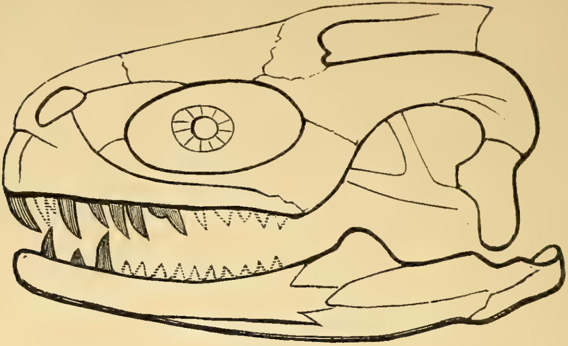
2. *The facts of Palæontology* display a certain *sequence* in the evolution of animals. First in point of time, in the primary rocks of the earth, appeared the multiform class of invertebrates; after these came fishes; then reptiles; and lastly, in secondary rocks, we find the earliest traces of birds and mammals.

Perhaps no creatures are further apart in structure and in function than a crocodile and a wren; but fossil forms show us a complete gradation from one to the other.

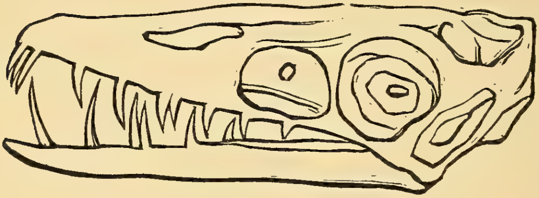
We learn from oolitic strata that before the advent of birds there existed saurians that sometimes walked on their hind limbs, and others that hopped on the ground after the manner of a sparrow. There were flying lizards with short tail, keeled breast-bone, and a pneumatic skeleton (its cavities filled with air) like a bird; while the feathered Archæopteryx, with its 20 caudal segments or tail-bones and its sternum without a keel, in these points resembled a reptile.

With respect to saurians themselves, we may contrast the huge head of Magalosaurus (*fig. G. See next page*) with the small skull of Pterodactyles, one of whom (*P. Crassirostris*, *fig. H.*) had jaws armed with socketed teeth, while another (*P. Pteranodon)* had toothless jaws encased in a bird-like beak; and as regards birds alone, the jaws of the *Ichthyornis dispar*, with recurved teeth sunk in distinct sockets, and those of *Hesperornis regalis*, with a terminal horny envelope, but also furnished with numerous conical teeth sunk in a continuous groove, may be compared with the strongly denticulate jaws of *Odontopteryx toliapicus*, (*fig. I.*) and these, in turn, with the roughened mandibles of the existing Spur-winged Goose (*fig. J.*)

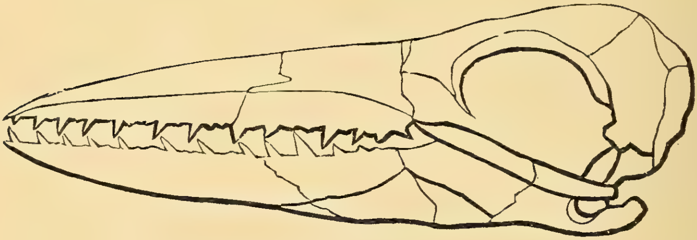
3. *Homology* deals with organs that are structurally alike, but which discharge different functions. The fin of a seal, the wing of a bird, the foreleg of a dog, and the arm of a man, though each performs a different office, are all built up of similar bony elements, which bear a striking and sometimes a close resemblance to each other. Some years ago, a bone which was found in the Victoria cave in Yorkshire, was declared by Professor Busk to be a human fibula; but after a while he saw reason for thinking that it was the fibula of a cave bear. The present writer has seen this fibula, and by the side of it the fibula of a man, and, though familiar with human anatomy, he feels sure that he could not have told one from the other. Why should there be such a close similarity between the corresponding bones of animals of the same class unless such animals are related by community of descent? Why should the possession of seven cervical vertebræ, or neck bones, be a general characteristic of mammals, whether the neck be immensely long as in the giraffe, or quite rudimentary as in the whale. "If it be urged," says Mr. Spencer, "that though for "the whale's neck one vertebra would have been equally good, "and though for the giraffe's neck a dozen would probably have "been better than seven, yet that seven was the number required "to make mammals correspond to an arbitrary type, such a view "is abruptly dissolved by the fact that this possession of seven "cervical vertebræ is not an absolutely universal characteristic of "the mammalian class." Such correspondences at once become intelligible when they are regarded as due to community of descent, or as instances of a wide reaching family likeness.



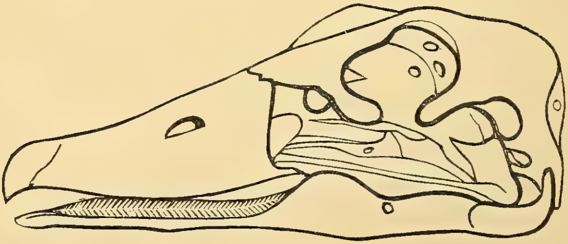
[*Fig. G.*]



[*Fig. H.*]



[*Fig. I.*]



[*Fig. J.*]

4. *Rudiments.*—Organs or parts of organs that have ceased to perform any function, and especially such as, from whatever cause, have become withered, wasted, or attenuated, are called rudiments.

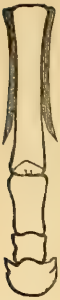
The wing of the ostrich is a rudimentary organ. In this animal the bones of the skeleton are almost entirely destitute of the air-cells which give so much lightness to ordinary birds. The great size and strength of its legs, however, render its pace in running exceedingly swift. The changes that we see in the domestic duck, which walks more and flies less than its wild parent, have in the ostrich extended much further, and we find here that the wings are small in size and quite incapable of flight, though they possess bones which both in number and in form agree with those of the wings of other birds. We can have no hesitation in attributing the rudimentary condition of the wing of the ostrich to its *disuse.* Some rudiments are so shrunk and minute as hardly to be explained in this way. After an organ has ceased being used, and has become in consequence much reduced, how can it be still further lessened until the merest vestige is left, as in the apteryx, and other wingless birds ; and how can it be finally quite obliterated? It is scarcely possible that disuse can go on producing any further effect after the organ has once been rendered functionless. "Some additional explanation," says Darwin, "is "here requisite, which I cannot give."

The additional factors are probably these two :—1. Hygroscopic and thermic influences. The drying influence of the air and the astringent action of cold on disused external organs. In some observations made of the metamorphosis of lizards, it was remarked that the gills and tail-fin seemed to shrivel by a simple drying process, through the action of the air, in opposition to a true absorption by the vital processes of the animal itself.

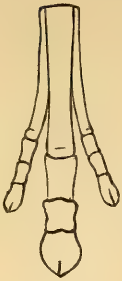
The effects of cold may be shown as follows :—Mice having become troublesome on the arctic island of St. Paul, a seal-fishing station, *cats* were brought to keep them in order. In *three generations* these cats not only became shorter in the body, and covered with a thicker fur, but they *lost a greater portion of their tail.*

2. The second factor is that organs in process of evolution are able to grow at the *expense* of those that are not required; whereby the latter must undergo a progressive diminution.

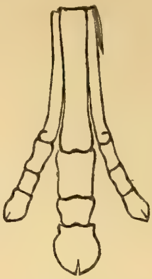
It is well known that the existing horse walks on the extremity of a single gigantic toe. The foot (leg), however, has two small "splint-bones," one on each side, which are rudiments of ancestral digits (*fig. K.*). The horse's precursor in Pleiocene times was *Hipparion*, an animal about the size of an ass, which had these lateral toes structurally developed, but small and functionless (*fig. L.*). The Meiocene horse, *Anchithernim*, about



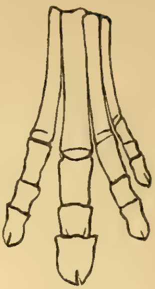
[*Fig. K.*]



[*Fig. L.*]



[*Fig. M.*]



[*Fig. N.*]

the size of a goat, walked on three perfect digits and had, beside, a fourth in a rudimentary state (*fig. M.*); while the earliest ancestor known, the Eocene *Orohippus*, no larger than a fox, had four digits to its front feet (*fig. N.*) and three to those behind.

We are thus able to see that an enormous development of the size of an animal, and of organs that it requires, is coincident, at first with a rudimentary condition, and at last with a complete disappearance of organs that are no longer needed.

HUMAN RUDIMENTS.

MAN has a number of rudimentary organs. The caruncle (of the eye) is a rudiment of the nictitating membrane of other animals (sharks, &c.). The skin muscle which is so largely developed and so useful in many mammals, is found in the neck *(platysma myoides)* where it is quite inactive.

One of the most interesting of man's rudiments is his external ear, a crumpled and contracted organ, furnished with a number of muscles which are altogether powerless and useless at the present time. But we can have no doubt at all that some of our ancestors were furnished with large, pointed, and highly movable ears. [*See Plate, fig. F.*]

The male mammæ are rudiments, and the fact has given rise to an interesting inquiry with reference to the couvade.

The couvade is a curious custom by which, when a mother gives birth to a child, the father goes to bed and is waited upon. It is practised in South America, in Greenland, Kamskatka, West Yunnan, Borneo, in the North of Spain, in Corsica, and in the South of France. Mr. Octavius March wrote to Mr. Darwin in 1875, asking him whether, in connection with the fact that male mammals possess mammæ, he thought it possible that the couvade had its origin in an early habit of the male sex to take part in the nourishment of the offspring. Mr. Darwin replied as follows. "The couvade has always seemed to me the most extraordinary of "all the odd customs followed by man. Your idea is new to me, "and very ingenious; but I do not think that it can be admitted, as "the period when male mammals suckled their young must have "been so immensely remote, seeing that rudimentary mammæ "are common to all orders, including the marsupials."

Neither correspondent seems to have known that in some African villages, as attested by Livingstone and other travellers, elderly men with well-developed mammæ are employed as wet nurses in suckling the young.

The fact must here be noticed that an animal's form becomes modified in consequence of a long continued alteration of its habits.

We might feel sure that, if animals had at any former period entirely changed their mode of life, we should find in proportion to the length of time that had elapsed since such change began, some organs would have become modified to suit the altered conditions, and other organs not needed would have become rudimentary. At various times, creatures that used to live on the land have been driven, in search of food, to betake themselves to the water. Two instances can be given of this transfer, in its incipient stage. "In the case of the water-ouzel the acutest "observer," says Mr. Darwin, "by examining its dead body would "never have suspected its subaquatic habits; yet this bird which "is allied to the thrush family, subsists by diving—using its wings "under water, and grasping stones with its feet. All the Hymen-"opterous insects are terrestrial, except the genus Proctotrupes, "which often enters the water and dives about by the use not of "its legs, but of its wings, and remains as long as four hours "beneath the surface; yet it exhibits so far no modification of "structure in accordance with its abnormal habits." Some internal modification, however must necessarily have taken place, especially as regards its organs of respiration.

An instance can be given of an older stage of this transfer, so that a change of structure visibly exists. The carnivorous mollusc Ianthina, is thought to have taken to the sea in recent times because it has never been found in a fossil state. Its shell closely resembles that of a common land snail. Its foot secretes a remarkable structure, considered to be the analogue or corresponding organ of the operculum (lid). This consists of a large raft composed of numerous horny vesicles filled with air, to the under surface of which the animal attaches its eggs, and thus floats about on the surface of the Atlantic in great numbers.

In early tertiary times, when the ancestors of the seals took to the sea, whales had already become entirely pelagic. Some seals, the Otaridæ, have four limbs on which they can support themselves. The hind feet, however, appear only as flappers, while the corresponding legs are united with the tail by the general integument of the body. In the common seal, *phoca vitulina*, the front limb is buried beyond the elbow in the general integument, but the flexible wrist allows the weight of the body to be supported by the palm. The hind limbs, on the contrary, are permanently stretched out and turned backwards, under the skin of the trunk, so that the conjoined hind limbs and tail are put to the same use as the caudal fin of a cetacean.

The whale, which is as much a mammal as a cow, has its limbs modified even more than those of the seal. Its arm-bones are short, laterally compressed, and without movement upon one another. The fingers do not exceed five in number, but some of these always have more than three phalanges (knuckle-bones), constituting a fin. The hind limbs are in most whales entirely absent, but in the Balænoidea they occur in the highly rudimentary form of ossicles, or small bones, which lie on the outer side of the pelvic plates.

So much for rudiments; though one highly important fact remains to be stated. It is a rule without exception, that a rudimentary part is of greater relative size *in the embryo* than in the adult; so that the organ at this early stage is less rudimentary, or even cannot be said to be in any degree rudimentary. Hence rudimentary organs in the adult are often said to have retained their embryonic condition.

The young of an animal, prior to birth, or before leaving the egg, or previous to attaining the mature form, is an embryo. An embryo is an animal in its fœtal state. Larvæ are active embryoes.

6. *Embryology*, or the history of the germ, is the history of Descent. In other words, the series of forms through which the individual organism passes during its progress from the egg-cell to its fully-developed state, is a representation of the long series of forms through which the ancestors of that organism have passed, from the earliest periods down to the present time.

In the majority of ruminants, or cud-chewers, the lower jaw *alone* is furnished with incisors or front teeth; the only exceptions being the camels. Now the fœtal calf has incisors also in the *upper* jaw; but *they never cut through the gum*. Hence, we are confident that the calf's distant ancestors had incisors in both jaws. We draw a similar inference as to the ancestors of the whale, from the fact of the presence of teeth in the embryo, though it is well known that the adult animal has not a tooth in its head. So molluscs that in the perfect state are naked, often possess a shell while they are in the egg, where, clearly, it can be of no service to the embryo. It is a manifest mark of Descent.

HUMAN EVOLUTION.

IF we were to go over a palace, under the impression that it had been recently planned and built, we should expect to find, from the foundations to the roof, a harmony between the design and the structure ; and assuredly we should be surprised to discover that the architect had first used his materials to build a hut ; then, that having pulled portions down, he had rebuilt them into a cottage ; and then, that having added storey to storey and room to room, not with any reference to a palace, but wholly with reference to the way in which houses were built in ancient times, he had at last, in the completed structure, left here and there portions of the old hut and remnants of the dismantled cottage.

On going over a castle we are often able, by making similar discoveries, to gather a good deal of its history ; to point out that formerly the edifice was much smaller ; that at some previous time a bastion had been built out, a doorway closed up, or a moat filled in ; that its defences, which at a certain period were adapted to one kind of warfare, had been subsequently modified to suit another. In short, an archæologist would soon be able to establish the fact that the structure was not raised in one generation from one design, but contained within itself the evidence of a progressive evolution and adaptation through many centuries. Nor would it alter our convictions to find that Parallax believed that it was built last week ; or that our courageous priest, were he still alive, was of opinion that the closed-up doorway and the filled-in moat were by no means marks of antiquity and evolution, but were proofs of the inscrutable wisdom of the architect's original design, and were altogether past comprehension by modern minds.

The germ-cell of the human egg, which is only $\frac{1}{120}$th of an inch in length, resembles the adult form of an amœba or of a protococcus.

The first heart of the human embryo has a structure such as appears permanently only in animals like worms:—a simple pulsating chamber.

As the embryo assumes its vertebrate character, it developes certain gill-clefts [*See Plate*, *fig. man*, *A.*] on each side of the neck, up to which arteries run in curving branches. [*See Plate*, *fig. D.*] This arrangement which remains constant in the fish, and which indeed is suitable only for a water-breathing apparatus, soon undergoes modification [*See Plate*, *fig. man B.*] and becomes entirely altered [*See Plate*, *fig. E.*] before the fœtus is required to breathe air. The useless vessels are generally absorbed, but in some instances remain as rudiments.

At a later period, there is a movable tail considerably longer than the legs, as is permanently the case in many mammals.

As fœtal evolution progresses, we find the arms longer than the legs, the soles of the feet turned towards each other, and the great toe projecting sidewise from the foot, as in adult apes; while during the sixth month the whole body is covered very thickly with hair, extending even over the face and ears, everywhere indeed save on the lower sides of the hands and feet, which are also bare in the adult forms of monkeys. Thus we may tell our valued friend, who goes about like a Manx cat, protesting that at any rate *he* is not descended from a monkey,—we may tell him that he himself was once covered with hair from head to foot; and that his own blameless person was once adorned with a movable tail, whatever may have been the case with his ancestors.

As the different stages of fœtal development represent not only the changes through which the entire race, through countless ages, has passed, but represent also what are permanent forms in some animals, it might be asked, if the fœtus were removed from the parent at one of these early stages, would its development be arrested, and would it remain permanent in its fish-form, or in its quadrupedo-caudal form, as the case might be?

The common eft of our ponds passes a good deal of its time in the water, and lays there a large number of eggs. The young one on emerging from the egg is furnished with water-breathing gills, which after some weeks are dropped, and the animal becomes an air-breather. As the Alps were slowly raised, and pools of water grew gradually scarcer, the efts in that part of the world, influenced by the law of Natural Selection, underwent certain changes which kept them in equilibrium with their environment, and became entirely terrestrial. Oviposition, being at last no longer possible in water, was more and more delayed so that now the Alpine salamander, as it is called, though it has at the commencement of the breeding season 40 to 60 eggs, yet matures only *two*, for which the remaining eggs serve as food material. Notice particularly that from the moment of its birth, the young is an *air-breather;* but *before birth*, three long, much branched, bright red gills hang from each side of the head, and envelope the whole body. They are of no possible use to the embryo, and disappear at birth. A German lady, Fräulein von Chauvin, removes a larva, in this stage of gill-possession, from the parent's body, and places it in water. It swims about at once, and seizes and devours earthworms. In a few days it sheds its gills and *acquires new ones*, developes a stout fin, and is fully fitted for aquatic life. For sixteen weeks it lives in the water as did its remote ancestors, and only then undergoes those ancestral metamorphoses through which its immediate parents never passed, to become like the latter a terrestrial animal.

A reference has been made to some resemblances of the human embryo to the adult ape. We may take this opportunity of pointing out other relations.

Among some savages (Kaffir, &c.) the canine teeth project much beyond the others, and open spaces between the teeth in the one jaw are left for the reception of the canines of the opposite jaw. Both these peculiarities are found, though in a much greater degree, in the higher apes. But in the very ancient human jaw of La Naulette, the projection of the canines is enormous.

Adult man further resembles the higher apes in being *without* a tail.

The Chimpanzee and the Gorilla readily stand and run erect; but their favourite attitude is leaning forward and resting on the knuckles of the hand. Now while the first joint of the human fingers is hairy, the second is bare, answering precisely to the condition in the hand of the apes just mentioned.

Both in the higher apes and in man the hair of the arms has a convergent direction *towards the elbow;* while the hair of the legs inclines *away from the knee.*

The negroid races have absolutely smooth and glistening skins. Hairy Europeans show reversion to an older type. The tendency to smooth skins would be strengthened in naked races by sexual selection. Among clothed races, this factor is lost; and hence, smooth-bodied negroes, transported to America and subjected to changed conditions of clothes and climate, *redevelope hair upon the chest.*

The only muscles which exist in man and have not yet been found in the apes, are two *(extensor primi internodii pollicis et perinæus tertius).* One of them is a muscle that assists in moving the thumb, and would be developed when the hand began to wield implements; and the other assists in placing the foot flat on the ground, and would be developed as erect walking came to be the practice of the race.

Both muscles are merely auxiliaries of other muscles, and both are sometimes *wanting in the human subject.*

On the other hand, the apes possess four muscles *(levator claviculæ, dorso-epitrochlearis, scansorius, et abductor ossis metacarpi quinti digiti)* all used in climbing, which are not usually found in man, though they *all do occur as varieties.*

In addition it may be noticed that several muscles (as supplementary muscular bundles in the biceps of negroes) frequently wanting in white men are nearly always to be found in persons of coloured races ; and that, whereas it is the rule in the Gorilla to have thirteen pairs of ribs, in certain negroid tribes thirteen pairs of ribs are sometimes present, and occasionally there is a sixth lumbar vertebra.

As regards the brain, all the convolutions found in man are represented in the cerebral hemispheres of the Chimpanzee. A child's brain is especially ape-like; its furrows are shallow, symmetrical, and few. With advancing years they increase in number, depth, and complexity ; and this increase is most marked in persons of the greatest mental activity.

It should also be observed that, relatively to their dimensions, fossil birds and mammals have smaller brain-cases than their modern representatives ; a fact which suggests the inference that intelligence has undergone a progressive evolution till it has reached, in the massive cerebrum of a man, the faculty of speech, and the power of transmitting accumulated knowledge by permanent symbols.

VOLUME OF BRAIN.

Ourang and Chimpanzee	26 c.i.
Gorilla....................................	35 c.i.
Papuan, smallest human	55 c.i.
Negro	82 c.i.
Average European	94 c.i.
Largest European	115 c.i.

In what relation do we stand to the apes ?

We have seen that the human ear is a rudiment, and that the hair of man and of the higher apes is directed towards the elbow and from the knee. But in monkeys the ear is in a still more shrivelled and rudimentary condition, and the hair of the limbs is directed uniformly towards the digits. These are facts which show, not that *we* have descended from *them*, but that they branched off from our Parent stock at some very remote period. Indeed, Prof. Huxley remarks that whatever part of the animal fabric, bones, muscles, or viscera, be selected for comparison, the lower apes and the Gorilla are found to differ more than the Gorilla and the Man.

What were our immediate prehuman ancestors ?

It has been well said by Prof. Dawkins that " if man were upon " the earth in the Meiocene age, it is incredible that he should not " have become something else in the long lapse of ages and during " the changes in the conditions of life by which *all the Meiocene* " *land mammalia* have been so profoundly affected that they " have been either exterminated, or have assumed new forms. " It is impossible to believe that man should have been an " exception to the law of change to which all the higher " mammalia have been subjected since the Eocene age."

In other words, in tracing back our descent, when we come to Meiocene times, we must expect to find our ancestors no longer exactly human. So that the exceedingly rude flints found in Mid-meiocene strata by the Abbé Bourgeois, and figured by Prof. Gaudry, were, if truly belonging to this horizon, the workmanship of a prehuman archæolithic race, from which man has been evolved. At present no traces of this form have been discovered, just as we have absolutely none of our palæolithic ancestors, who left their flint implements in the valley of the Thames in association with the bones of tropical animals ; and just as we have absolutely none of the men who have left the hills about Rochdale strewn with neolithic tools and chippings.

It appears, however, that in the argillaceous sandstones of Nevada, the tracks of several species of Pleiocene mammalia are accompanied by those of a biped resembling man.

It has been said that the closer the structural resemblance between man and apes, the more striking becomes man's mental and intellectual superiority, which would seem therefore to be due to a divine endowment.

But there are many examples of the fact that psychical development does not coincide with morphological likeness ; that mind and form do not always vary concomitantly. Anatomically there is very little difference between a bee and a fly, or between an ant and a beetle ; but how marvellous is the contrast between their mental powers, and how much more is one animal than the other able to bend external forces to its own use and advantage.

Before passing on to consider sensation and cerebration, it may be well to point out that one of the characteristics of a true theory is that it enables us to explain a number of difficulties otherwise inexplicable. Darwinism, for instance, solves all problems respecting the distribution of animal and vegetable life upon the islands and continents of the globe. Darwinism supplies the reason why, in their own habitats, some creatures are quickly displaced and supplanted by foreign ones with which they are brought into competition ;—as the Australian flora and fauna disappear before plants and quadrupeds imported from Europe, and as negroid races vanish before the white man.

Above all, it is only Darwinism that can account satisfactorily for the existence of parasites, those degraded organisms that devour the vital juices of beings infinitely higher than themselves, and inflict measureless pain not only on our own persons, but on the sentient bodies of our mute companions. It is hardly too much to say that every animal, if not every man, is infested by them. "They "crawl upon his surface, they burrow beneath his skin, they nestle "in his entrails, they float in his blood, they riot and propagate "their kind in every part of his frame." Organisms so excessively minute as to require the highest power of the microscope for their definition, the amount of whose conscious enjoyment must be almost nothing, produce, by their mere multiplication in the bodies of vertebrate animals, the fevers, inflammations, and even the consumption that cause such misery and make such havoc upon the earth. It would have tried the metal of the courageous priest now no more, to assert that these pests were the result of a special act of a benevolent Creator, and that they all followed Noah into the ark at the time of a universal deluge. But of two things, special creation and evolution, we must choose one.

THE SENSES.

THE evolution of the senses must be mentioned, though time fails us to consider it adequately.

Sensory organs are means by which the forces exerted by surrounding bodies are transmuted into affections of nerve—by which Dynamosis may become Neurosis,—and they are all specialised portions of the common integument. A hair is a prolongation of skin, and a vibrissa, or a stiff hair like a cat's whisker, is an organ of touch. And the stalked eye of the Crustacean is really a transformed limb with a sensitive tip. In order, however, to lead up to the evolution of mind, to follow Neurosis into Psychosis, we must describe more fully the evolution of the sense of sight.

In some animals of the humblest type, especially those which are *quite transparent*, the whole body is affected by light, as opposed to darkness. Professor Ray Lankester was of opinion that the eye of the vertebrates began to be evolved at the time when the ancestral head was completely transparent. It is known that in any organism, light tends to develope pigment grains. Pigment grains developed in any part of a transparent organism would, as absorbing light and heat, render *that part more irritable* by light or heat than the rest.

In some of the lower Mollusca, small coloured points, sometimes singly in the neighbourhood of the brain, and sometimes in considerable numbers on the edges of the mantle, are called ocelli, and are regarded as rudimentary eyes. These are not *organs of sight*, but parts of the body sensitive to light; and we can readily understand what this is, by closing our lids and moving the hand before the eyes.

While only a *general* sensitiveness to light exists, the intercepting of the sun's rays by something which throws a *large portion* of the creature into shade, is required to produce an internal change. But when there comes to be a specially sensitive spot, anything that casts a shadow *on that spot alone*, produces an internal change. The contrast between light and darkness being all that a rudimentary vision recognises, it is clear that nascent vision extends to those objects alone which are *just about to touch the organism*, either from their motion or its own. This amount of sight, therefore, as Mr. Spencer observes,* is little more than anticipatory touch. Hence in the earliest forms of sight, visual impressions are habitually followed by tactual ones. Now tactual impressions are habitually followed by contractions. From the Zoophytes upwards, touch and contraction form an habitual sequence. So that in a creature whose incipient vision amounts to little more than an anticipation of touch, there constantly occurs this succession :—1, a visual impression; 2, a tactual impression; 3, a contraction.

As we ascend to creatures having more developed eyes, we find an increase in the sphere of surrounding space throughout which external relations can establish corresponding internal relations. *A slight convexity* of the epidermic layer lying over the sensitive tract, first serves by concentrating the rays, to render appreciable *small* quantities of light; and thus brings into view the same bodies at a greater distance, and smaller or less opaque bodies at the same distance.

In certain starfishes, small depressions in the layer of pigment which surrounds the optic nerve are filled with transparent gelatinous matter, projecting with a convex surface, like the cornea in higher animals. The luminous rays thus concentrated would form an image.

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* See Spencer's "Psychology," from which is taken most of what immediately follows.

THE NERVOUS SYSTEM.

Now the evolution of a nervous system is a necessary concomitant of that specialisation which originates the senses. On the one hand, until the general sensitiveness is in some degree localised, the internuncial function (the telegraph office) of the nervous system cannot exist; and on the other hand no such localised sensitiveness can exist without something that answers to nerves; there must be a tract of least resistance along which molecular vibrations flow. A nascent sense of sight, therefore, implies a nascent nervous communication, and along with a nascent nervous communication we may see the first illustration of the growth of intelligence.

If psychicāl states follow one another, time after time, in a certain order, so as eventually to become inseparable; then it must happen that if, in the experience of any species, a visual impression, a tactual impression and a contraction are continually repeated in this succession, the several nervous or psychical states produced will become so consolidated that the first cannot be caused without the others following. There will thus occur a contraction in anticipation of touch; *and we see the origin of reflex action.*

When vision is further developed, the same bodies will be discovered at greater distances, and smaller bodies will be discovered when close by. Both of these must produce obscurations which are faint in comparison with that obscuration produced by a large body about to strike the creature's surface. But now mark the accompanying experience. A faint obscuration will *not*, like an extreme one, be habitually followed by a strong tactual impression and a subsequent contraction. If caused by a great mass passing at some distance, there will probably be no collision —no tactual impression at all. If caused by a little mass which is very near, the collision that follows will be comparatively slight; so slight as not to cause a violent contraction, but only such tension in the motor apparatus as is seen in any creature about to seize upon its prey.

INSTINCTS.

Now, a creature possessing this somewhat improved vision will, by a partial obscuration of light, have its muscles brought into a state of partial tension—a state fitting them either for the seizure of a small animal, should the partial obscuration be caused by the pending collision of one; or for sudden retreat into a shell, should the obscuration be *increased* by the near approach of a larger animal.

So, from the simple advance just indicated there arises a somewhat greater speciality and complexity in the inner relations answering to outer relations; and we see how one of the *simpler instincts* will, under the requisite conditions, be established by accumulated experiences.

First we got *reflex action*, and now we have *instinct.*

"Instincts are as important as corporeal structures to the "welfare of each species. With a changing environment, slight "modifications of instinct would become profitable to a species; "and when instincts do vary, ever so little, then natural selection "can preserve and continually accumulate variations of instinct to "any extent that is profitable."

MIND AND REASON.

Very low in the scale of animal life, the possession of some general intelligence, that is, of *reason*, becomes manifest. "Even the headless oyster," says Darwin, "seems to profit by "experience;" and this is the test of *rational* as distinguished from *instinctive action.*

There are, then, three steps in the evolution of mind. First, the origin of reflex actions; second, the development of instinctive actions; and last, the attainment of reason. The most complicated instincts may be formed out of purely reflex actions by natural selection; and instinctive processes pass into rational processes when they become too complex to be performed unhesitatingly. In the pause that occurs there is time for remembered experiences to operate as motives, furthering or hindering the proper reflex of a stimulated sense; and the resultant action is known to us as "volition." An animal capable of deliberate instead of thoughtless, instinctive, or unconsidered action is better adapted than others to a changing environment. Rational processes, however, when they are often repeated, become *habits*; and habits may become fixed by heredity as *secondary instincts.*

But the subject of intelligence may be regarded from another point of view. Mind-stuff, says Clifford, is the reality which we perceive as matter. A moving molecule of inorganic matter does not possess mind or consciousness; but it possesses a small piece of mind-stuff. When molecules are so combined together as to form the film on the under side of a jelly-fish, the elements of mind-stuff which go along with them are so combined as to form the faint beginnings of sentience. When the molecules are so combined as to form the brain and nervous system of a vertebrate the corresponding elements of mind-stuff are so combined as to form some kind of consciousness. When matter takes the complex form of a living human brain, the corresponding mind-stuff takes the form of a human consciousness, having intelligence and volition.

There is a well known rotifer whose microscopic body is provided with a very active tail, which is armed at its extremity with strong pincers. "I have seen," says Mr. Romanes, "a small "specimen of this rotifer seize a much larger one with its pincers. "The large rotifer at once became very active, and swinging "about with its burden until it came to a piece of weed, it took "firm hold of the weed with its own pincers, and began the most "extraordinary series of movements, which were obviously directed "towards ridding itself of the encumbrance. It dashed from side "to side in all directions with a vigour and suddenness which "were highly astonishing, so that it seemed as if the animalcule "would either break its pincers or wrench its tail from its body. "No movement could possibly have been better suited to jerk off "the offending object. But not less surprising was the tenacity "with which the smaller rotifer retained its hold. This trial of "strength, which must have involved an immense expenditure of "energy in proportion to the size of the animals, lasted for several "minutes, till eventually the smaller rotifer was thrown violently "away. The entire scene was as like intelligent action on the "part of both creatures as could well be imagined."

Some animals, like the bee, profit by experience very quickly. Others, higher in the so-called scale of life, very slowly. Prof.

Mobius proved that a pike requires three months to establish an association of ideas. A glass partition in a tank separated some minnows from a pike, which repeatedly dashed its nose against the invisible wall, in fruitless efforts to catch the minnows. At the end of three months the pike, having learned that its efforts were of no use, ceased to continue them. The sheet of glass was then removed; but the now firmly established association of ideas never became disestablished, for the pike never afterwards attacked the minnows, though it fed voraciously on all other kinds of fish.

But an ability to profit by experience rises in some animals to a power of judgment. Dr. Rae, the naturalist, knew a dog in Orkney which used to accompany his master to church on alternate Sundays. To do so he had to swim a channel about a mile wide; and before taking to the water, he used to run about a mile to the north when the tide was flowing, and a nearly equal distance to the south when the tide was ebbing, almost invariably calculating his distance so well that he landed at the nearest point to the church. How the dog, says Dr. Rae, managed to judge of the strength of the spring and neap tides at their various rates of speed, and always to swim at the proper angle, is most surprising.

CEREBRATION.

As regards vertebrates, it is a remarkable fact that the cells of the brain and of the spinal cord are developed from the same portion of the egg, the upper embryonic layer, as the cells which form the skin and the organs of special sense. It is remarkable because, between these structures, derived from similar and contiguous elements, but becoming finally so different and so separate, the most intimate relations continue through life.

Every sensory organ is connected by means of nervous filaments with a portion of the brain; so that when a change has been wrought by some external force on any sensitive surface, a molecular wave is transmitted to appropriate cerebral centres.

Such a wave of energy may be diffused through the brain and forthwith expend itself in exciting muscular movements. Or it may pass into a state of dynamic tension—the cerebral cells playing the part of storage-cells—and the molecular or molar motions to be ultimately performed may be indefinitely deferred.

The brain, which is thus a register of sensations, is able in the same manner to record sensory changes that have not even been consciously perceived. Moreover it not only contains a symbolic representation of much of an animal's past environment; it likewise represents in some degree, by the law of heredity, the experiences of the race.

An organism whose inner relations thus answer to outer relations, both present and past, may possess a sense of the continuity of life and a feeling of personal identity.

Waves of molecular motion set up by sensory changes continually pass through appropriate groups of storage-cells, increasing their tension and augmenting the organism's potential recollection; or, spreading through wider groups, they may excite interaction between cerebral centres, and occasion memories or trains of thought. We hear the scream of a child; we think of possible peril and of possible succour. A wave of energy has passed through the storage-cells that represent those ideas; and perhaps discharges some of their accumulated force in remedial effort.

When local action takes place in the brain, and feeble currents flow among groups of storage-cells, "unconscious cerebration" and unremembered dreams may be the result. The passage of more vigorous intracerebral waves coincides with reasoning processes and with conscious mental operations. The "mechanical equivalent" of thought has not yet been determined, but it is indicated by the formation and excretion of a quantity of phosphatic and nitrogenous waste.

When the brain is exhausted by work, or when its nutrition is retarded by anæmia or by age, memory is enfeebled and every new association of ideas becomes difficult or impossible; and when its blood-supply is arrested for a single instant, consciousness ceases. In fact, whatever impairs the integrity of cerebral protoplasm—cold, chloroform, pressure, poison—puts an end to cerebral function. Drugs introduced from without, waste-matter from internal organs unduly retained, make ideation irregular and delirious; and when the nervous centres are perturbed or interrupted by disease, there arise the delusions and hallucinations of the insane.

And now what divisions of psychological evolution remain to be noticed? Emotion; Art; The Moral Sense; Religion; Science. Let us glance at them in order.

EMOTION.

We have all seen, in the higher vertebrates, evidences of such emotions as fear, affection, passion, pugnacity, jealousy, sympathy, pride, reverence, emulation, shame, hate, curiosity, revenge, and cruelty. Some of us have seen proofs of the emotion of the ludicrous, and even of the emotion of the beautiful. Indeed, facts connected with the fertilisation of flowers by insects, and with what Darwin called sexual selection, show us that a sense of the beautiful is very widely diffused. Let us recollect, however, that beauty is not an entity, or an external object; it is a pleasurable psychical or nerve state, following or accompanying a visual impression. A face or an ornament that some races look upon with delight others regard with abhorrence.

ARTS AND ART.

Animals practise various "industrial arts." Witness the wonderful dam-building beaver; the spider and his trap-door; ants who keep animals in captivity for the sake of their secretions, as we keep cows, and who cultivate for food a kind of fungus, as we grow mushrooms. As regards art, properly speaking, we may remember the birds that build and decorate bowers of public assembly, and that adorn plots of ground with shells, and twigs of leaf. "Music," says Mr. Gurney, "is a primeval art "which we share with the brutes. Sounds of a peculiar arresting "quality, belonging to musical *material*, sounds coloured with a "distinct musical *timbre*, as opposed to the uncertain neutral "sounds of ordinary life, are often producible at the will of a "creature, by a conscious and exciting effort. And in the "deliberate exercise of this power, for the sake of pleasure to the "possessor or to the members of his tribe, we see a *veritable art* "*germ*. And not only so; the germs of *form* are also found in "the animal kingdom, in that appreciation of the regularity of "recurrence which, at its simplest is as purely sensuous as pleasure "in formless sound, and within the reach of comparatively simple "nervous organisations. It is the same recurrence which, when "it assumes true regularity, we call rhythm; and which, in the "shape of a basis of regular accents, remains, and will remain, to "the end of time a characteristic of all series of sounds possessing "wide permanent charm for human ears. It is worth noticing "that the prominent quality of savage performances, to a civilised "ear, is their monotony and hideousness; and though many have "remarked the precision, few have remarked the high development of their rhythmic element. Among the Zulus, not only is "the device of 'syncopation' effectively used, but the still more "*recherché* effect of double against triple time."

Let us contrast the performance of these poor mammals with the soft cadence of the cuckoo, the sweet melody of the nightingale, and the impassioned song of the skylark; and say where is the higher art!

THE MORAL SENSE.

THE development of the moral sense has taken place along two lines.

1. There is evolution on what is called the "utilitarian" line, based on the grand distinction between the useful and the useless, which every animal must make in the pursuit of food or in the construction of some kind of abode. That the moral sense has been in a large degree evolved in this manner is shown by the meaning of our own language; by the origin of the words "right" and "wrong." Right means straight, and wrong is wrung, twisted, bent, crooked. "Good" also means suitable or fit, and comes from a root *gad*, whence we get our word "to gather." We gather what is suitable, and what is suitable is good.

2. The other deep-lying distinction from which is evolved our moral sense, is the difference between the clean and the unclean. Mr. Watts has told us how carefully swallows prevent their nest from becoming fouled. We are constant observers of the way in which many animals clean themselves and their offspring. Alexander Agassiz has seen an echinus rapidly passing particles of

excrement from forceps to forceps down certain lines of its body in order that its shell should not be soiled, and I had in captivity a little newt which left all his droppings in one part of his cage. Here again language comes in evidence. We continually speak of "dirty" actions, or of "bad" conduct; and both words signify ordure. On the other hand, "pure" means clean.

No doubt both classes of actions, the selection of what is suitable, and the avoidance of what is foul, first as instinctive and then as rational actions, depend upon the primary and universal instinct of self-preservation. And across these two fair lines of moral evolution all the false religions of the world have come, with their artificial observances, their sham sins, and their pretended atonements. Not, however, even this, without some benefit to our race; for even by such means as these conscience has been quickened, and social forces strengthened, and a desire has arisen among men to stand well with their fellows.

But humbler creatures have a similar feeling. "A Skye-terrier "of mine," says Mr. Romanes, "was only once in his life known "to steal; and on this occasion when very hungry, he took a "cutlet from a table and carried it under a sofa. I saw him "perform this act of larceny, but pretended not to have done so, "and for a number of minutes he remained under the sofa with "his feelings of hunger struggling against his feelings of duty. "At last the latter triumphed, for he brought the stolen cutlet and "laid it at my feet. Immediately after doing so, he again ran "under the sofa, and from this retreat no coaxing could draw "him. When I patted his head, he turned away his face in a "ludicrously conscience-stricken manner." Thus self-consciousness and conscience are developed out of an experience of "rewards and punishments," of praise and blame, of contentment and chagrin, by perfectly natural processes.

RELIGION.

By what process has the religious sense been evolved?

Early man seems to have regarded the faculty of respiration as the test of life. "Spirit" means breath, and the word "animal" signifies a breather. Psyche, the Greek word for soul, comes from the verb "to breathe;" and we read that Adam became a living soul when he received the breath of life. A still earlier, deeper and ruder test of life, however, is the test of motion. The old English word "wight" comes from a root signifying that which moves.

Animals consider all things to be alive until convinced by experience that they never, on any occasion, *move by themselves.*

Mr. Romanes relates the following experiment. "I one day "attached a fine thread to a dry bone, before giving my dog the "latter to play with, and after he had tossed the bone about for "awhile as usual, I stood a long way off, and slowly began to "draw it away from him. As soon as he perceived that the bone "was really moving on its own account, his whole demeanour "changed, and, rushing under a couch, he waited horror-stricken "to watch the uncanny spectacle of a dry bone coming to life."

It was, at one time, supposed that the planetary orbits were circular, and that the planetary movements were uniform. The great astronomer Kepler discovered, however, that the planets move in elliptic orbits, with a velocity which periodically increases and diminishes, describing equal areas in equal times. (A.D. 1619). These facts, though they are as Newton showed (1686), a necessary consequence of the law of gravitation, seemed so unaccountable to Kepler himself, that he came to the belief that the planets were living animals who moved by their own volition.

Similarly, it is clear, from the actions of a horse, that he attributes *personality* to *whatever moves*, inasmuch as he will shy with terror from a fluttering leaf or from a trundled hoop. This natural mental process of the horse we may call "hippomorphism," just as when man attributes a personality to the forces of nature we may call it anthropomorphism; and anthropomorphism is the root of the religious sense.

The truth of this statement is manifest in the facts of Fetichism and of Totemism; and it can be abundantly proved in religions of a higher order.

In a recent *Peking Gazette*, is published a memorial of the military governor of Urumtsi, praying the Emperor to confer a tablet on the deities of a mountain in his district, in recognition of various acts of supernatural interposition. In this mountain there is a large lake of unfathomable depth, upon the waters of which the inhabitants of the whole surrounding country rely for the irrigation of their land. Of recent years, however, it appears the springs had shown signs of exhaustion, and much anxiety had been felt on this account. Last year (1881) a temple dedicated to the divinities of the mountain was erected, and scarcely had it been completed when the water in the lake rose more than a hundred feet, and has ever since afforded an unfailing supply. The assistance of these deities has been invoked with *unvarying success* on many occasions when locusts threatened to devastate the country, or when snow was urgently needed for the protection of the crops. The memorialist thinks that important services such as these should not go unacknowledged, and he begs therefore in accordance with the wish of the inhabitants to address the Emperor on the subject. His Majesty replies, graciously conferring the suggested tablet on the mountain divinities.

Not very differently was the grateful spirit of the German Emperor displayed during the late European war. After special acts of successful carnage he made haste to chaunt the praises of *his* bellicose Teutonic divinity, to whom, indeed, signal honours were accorded at the close of the conflict. A like gratitude is seen in a Vedic hymn, dedicated to Parganya, one of the deities of the clouds, often addressed as supreme. Herein we read—"Stop now, Parganya; thou hast sent rain; thou hast made the "deserts passable and hast caused the plants to grow; and thou "hast obtained praise from men." It would seem, moreover, that when the human mind has long accustomed itself to regard the more variable phenomena of nature as influenced by religious observances, it acquires a belief that even the stupendous uniformities of the solar system are subject also to personal caprice. Thus, Confucius taught "Honour the sky: reverence the manes "(or spirits of the dead); if you do this, sun and moon will keep "their appointed time."

Before going further, it is necessary to say, in order to prevent misunderstanding, that the word "person" is used here in its only legitimate sense as signifying a human being. Applied to a divinity the term would connote a perfect human form and the highest degree of human faculties or affections, such as anger, love, purpose, regret. In vertebrates these mental states are known as psychoses, and are always found associated with cerebration, being discharged as functions of the brain.

The growth of the religious sense, when once it has risen above fetichism, is remarkably illustrated in the history of the early Hebrews. The intensely personal nature of their divinity is seen in the statement that in his image and after his likeness man was made (Gen. i, 26). Before they reached the magnificent conception of One God, it is clear that they regarded Jahveh as their own tribal divinity. "Wilt not thou possess that which "Chemosh thy god giveth thee to possess? So whomsoever Jahveh "our god shall drive out from before us, them will we possess." (Judges xi, 24). Sometimes, too, "they forsook Jahveh the god "of their fathers, and followed the gods of the people that were "round about them and provoked Jahveh to anger." (Judges ii, 12). And though they ultimately attained to the sublime belief that purity and uprightness are better than the ceremonial observances of any religion (Psalm LI, 16, 17), the tendency to attribute to their divinity the possession of human senses and to supply them with an appropriate stimulation, lingered to the last.

As regards the sense of smell, we find Ezekiel (vi, 13) speaking of the places where men offered sweet savour to all their idols; and it is related (Gen. viii, 21) that Noah offered burnt offerings and that Jahveh smelled a sweet savour. As regards the sense of taste, it is recorded (Gen xviii, 1) that Jahveh appeared unto Abraham, who, because he had thus found favour in his Lord's sight, prepared a meal with cakes of fine flour and a calf dressed with butter and milk; delicacies which were eaten by the divinity, under a tree. As regards the sense of sight, we find that bright colours, blue, purple and scarlet were employed for sacerdotal purposes (Exod. xxvi, 31—xxviii, 31); that a lamp, like the vestal flame, was caused to burn continually (Lev. xxiv, 2); and that David danced before Jahveh with all his might (II Sam. vi, 14). While as regards the sense of hearing, it is sufficient to recall that Jahveh was to be praised in his sanctuary (Ps. CL, 1, 3, 4, 5), with the sound of the trumpet, of the psaltery and harp, of stringed instruments and organs, and of high-sounding cymbals, which were directed to be played skilfully, with a loud noise (Ps. xxxiii, 3).

Of course, in this enlightened country we have long since grown out of the grosser forms of anthropomorphism. But travellers tell us that in distant and degraded lands the senses of the local divinity are still soothed with incense, or refreshed with the spectacle of fruit and flowers; that priests dress themselves up in strange garments when they go into their temples; that sacred movements are still practised, and that the ear is smitten with the prolonged wail of intoned lament, and the tumultuous hubbub of a chorus.

SCIENCE.

As long, however, as natural phenomena were referred to a personal cause—as long as an outbreak of disease, for instance, was attributed not to a polluted water-supply, but to the retributive action of an offended local divinity, who smites his foes as one man will strike down his fellow—so long was Science impossible. For the function of Science is, not for example to attribute the failure of the grape crop to the immorality of Paris, but by exact observations to gain an *accurate knowledge of the linked causation of things.* And so, the idea of personality having failed to satisfy the mind, there has grown up the lofty conception of Universal Law, or Invariable Natural Order. And the discovery has been made that natural laws depend, not on any capricious arrangement, but on the rigid necessity of the case. We say, for instance, that it is a law that light varies inversely as the square of the distance; and we find that in point of fact it could not vary in any other manner.

So, likewise, we observe that bees prefer blue to all other colours, and we have reason to suppose that this is due to the ultimate chemical constitution of the colouring matter of plants. Changes in the colour of flowers occur in a regular order, yellow flowers passing into pink, as their structure becomes modified to receive the visits of insects; and pink flowers passing with a further modification of form, through red and purple to blue; but never in a reverse direction nor in any other order. There is thus a correlated variation between colour and structure. Now bees are the most highly specialised and the most flower-haunting of insects; and flowers, that they may secure fertilisation by the visits of bees, have acquired, under the influence of the law of natural selection, an ample secretion of attractive nectar. But highly modified flowers tend to become purple or blue, hence bees have grown to prefer these colours from their association with abundant stores of food.

In the same way, we find that law and order enter into conduct, the supreme affair of human life. "Moral maxims are ultimately "of the same nature as the maxims of any other craft; if you "wish to live altogether successfully, or happily, or worthily, you "must do so and so." "Whatsoever a man soweth that shall he "also reap." After groping in the dark for many millenniums, after long wanderings in the desert places of the earth, after trying all things and after failing in all things, have moral maxims been evolved.

Theft and lying are found to be less good, less fit to be gathered, than honesty and truth. Vice is unclean, and virtue is pure. The polygamy of the Jews has yielded to the monogamy of the Gentiles; even as war in politics, and protection in commerce, are being displaced by arbitration and by free-trade.

But after the moral sense, there will yet be evolved an intellectual sense. As the various systems of religion have helped to develope the former, the various systems of science are destined to bring about the latter. Inasmuch as each structural relation between the different parts of the brain, stands for some constant connexion of phenomena in the experiences of the race, as the teachings and methods of science become part of our organisation, there will arise a number of *intellectual insights*, the operation of which will ultimately be as certain and immediate as our ordinary sense-perceptions.

So much for evolution. Shall we, like the Fathers le Seur and Jacquier, still cling to what is proved to be false, or have we the courage to avow and to teach those things that we believe to be true? The soul of man, says Plato, is like a driver with two horses; one of them strenuous, docile, steadfast; the other turbulent, capricious, destructive, ungovernable. While our better nature has been slowly and painfully evolved, we know that our evil tendencies have been transmitted to us from primal and carnal ancestors. And if any should exclaim like the queen-mother,

> "O Hamlet, thou hast cleft my heart in twain,"

we may reply with him,

> "O throw away the worser part of it,
> "And live the purer with the other half."

ADDITUM.

It was altogether outside the province of this paper to refer to a First Cause. When we try to penetrate into the mystery of the origin of all things, one supreme difficulty meets us on the threshold and arrests our search. We cannot escape from our corporeity. The theologian and the philosopher speak of a First Cause in terms of humanity, attributing to It intelligence, emotion and will—states of which we know absolutely nothing except as associated with the possessors of a nervous system.

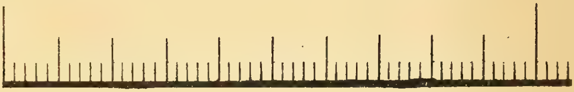
If the naturalist speaks of a first cause, it is, perhaps, in terms of the two inseparables, matter and force; and if he attributes to it law and order it is with the full consciousness that his knowledge of these relations is altogether drawn from his own sensations. Hence anthropomorphism is a constant which we cannot eliminate. It is certain, however, that there is nothing in the Darwinian theory of evolution antagonistic to a teleological conception of the universe, if only a first cause is not considered to be a "contradiction in terms." And it must depend on the mental quality of each man who believes in the necessity of a first cause, whether he ascribes to It a personal and paternal character swayed by a love for all creatures and employed in arranging the universe for their happiness—a faith that sustains and comforts a large proportion of mankind—or whether, finding himself unable to cast off an anthropomorphic bondage and perceiving in the phenomena which surround him a drift towards the useful and the clean and the good, "a stream of tendency "that makes for righteousness," he invests it with a quasi-personality not without a charm of its own.

In the story of evolution, of the struggle for existence, of the survival of the fittest, can we not faintly discern—such a man might say—the dim purpose of Nature and see some long, patient, persistent intention pursued through that lapse of time in which the whole geological record of our planet is no more than a flash in the darkness? Has it not been the unintermittent aim of Nature to burst or blossom at last into conscious thought; to sow here and there in the uttermost recesses of her empire the germs of life, and to nurse them through the ages into cerebral organisms, by which she may, as it were, herself lie still and think? For just as surely as our brains are part of our bodies, our bodies are part of the universe; made of the same elements, moved by the same forces, subject to the same change. And the problems that we consider and solve Nature thinks out too, in the brains that she has fashioned; and the sorrows that we feel Nature suffers also in the hearts that she has made. So then, to her lover's prayer, to the cry of a weary worker, Nature may answer thus:—

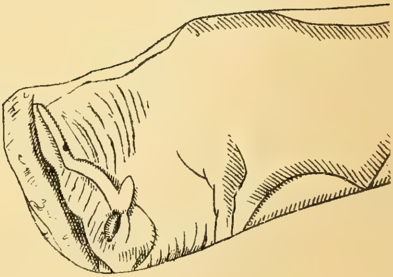
INVOCATION.

Lead me again, dear vision of delight,
With thy warm hand along the happy fields,
In sight of sombre mountains ranging round
The fitful gleam and glance of distant lake;
Beside the tumbling brook's wild melody,
Deep drawing into lungs the scented air,
The breath of many meadows cool and sweet.

Ah! vision of enchantment, come once more,
Thrill me with touch no human contact can;



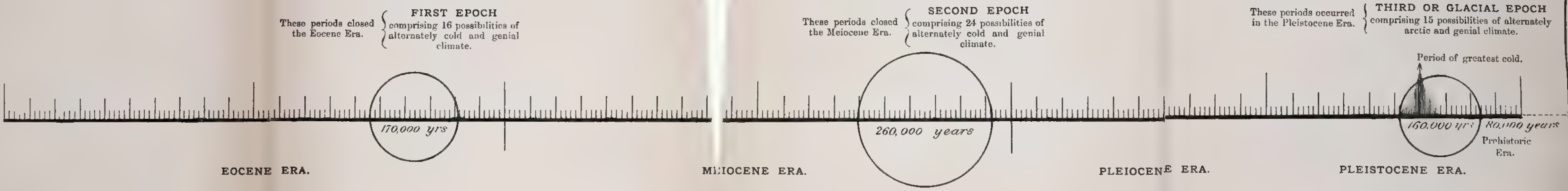
EOCENE



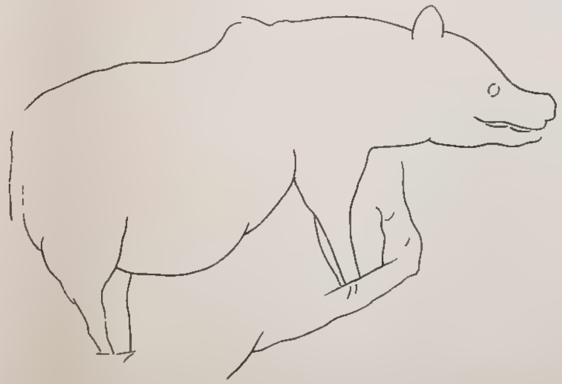
1. Mesolithic Man hunting the U

THE THREE LAST EPC OF TERRESTRIAL ECCENTRICITY,

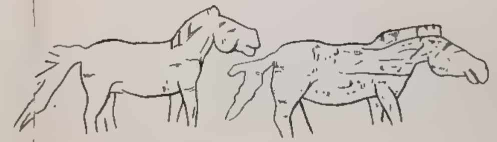
During which there were, in the northern hemisphere, many bilities of cold climate and of genial climate, each lasting about 10,000 years.
Each of the smallest divisio 10,000 years. The whole = 3,000,000 years.


These periods closed the Eocene Era.
FIRST EPOCH
comprising 16 possibilities of alternately cold and genial climate.
170,000 yrs
EOCENE ERA.
These periods closed the Meiocene Era.
SECOND EPOCH
comprising 24 possibilities of alternately cold and genial climate.
260,000 years
MEIOCENE ERA.
PLEIOCENE ERA.
These periods occurred in the Pleistocene Era.
THIRD OR GLACIAL EPOCH
comprising 15 possibilities of alternately arctic and genial climate.
Period of greatest cold.
160,000 yrs
80,000 years
Prehistoric Era.
PLEISTOCENE ERA.

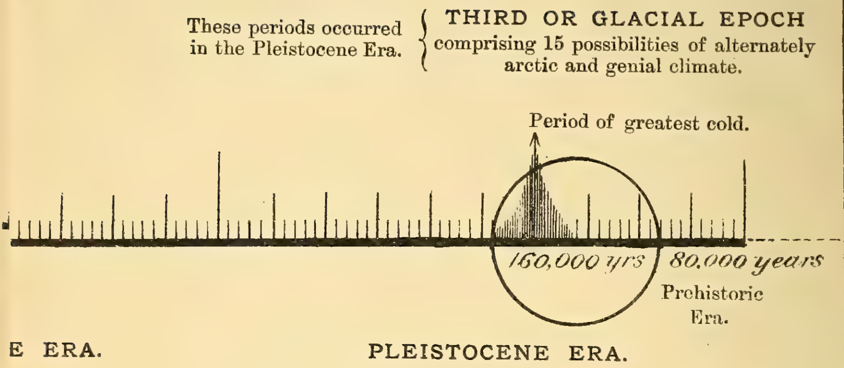
1. Mesolithic Man hunting the Urus, incised, by himself, on Antler.—DURUTHY CAVE.



2. Cave-Bear, incised by Mesolithic Man.—BAS-MANAT.



3. Horses incised on Antler, by Mesolithic Man.—LA MADELAINE.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THIRD OR GLACIAL EPOCH comprising 15 possibilities of alternately arctic and genial climate.
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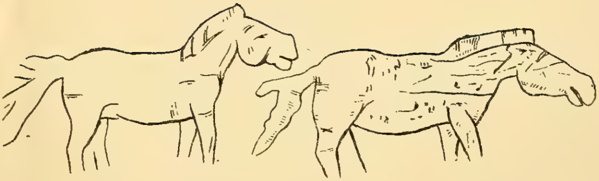

. Horses incised on Antler, by Mesolithic Man.—LA MADELAINE.

ANCESTRAL MAN;

OR,

FLINTS, AND WHO FASHIONED THEM.

QH
368
M35
1883

BY

H.enry C.olley MARCH, M.D., Lond.

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THE substance of the following Paper was read to the Rochdale Literary and Scientific Society, in February, 1881. It has been carefully re-written, and is now published because of the growing interest that most persons feel in the matter with which it deals. The principal authorities quoted are Ramsay, Dawkins, Croll, Haughton, Evans, Lubbock, Wilson and Tylor.

H. C. M.

THE PURPOSE of the present Paper is

(I.) to glance at the nature of the substance known by the name of Flint, and to make some attempt to read the riddle of its formation—a problem invested with unusual difficulties:

(II.) to indicate the kinds and characteristics of Flint Implements, and to point out their wide distribution:

(III.) to epitomise with clearness the Glacial Theory, in order to a better understanding of the way in which the various flint-workers were related to the periods of European Glaciation:

(IV.) to make a rapid survey of the races that have been called Archæolithic, Palæolithic, Mesolithic, Neolithic Prehistoric and Historic: and

(V.) to supply to the conclusions at which we shall arrive, certain remarkable linguistic confirmations, many of which will be now advanced for the first time.

I.—NATURE and FORMATION of FLINT.

SILICA, or the oxide of silicon, enters largely into the composition of granite, felspar, and sandstone; and occurs in a pure state as quartz and as silex or flint. Bands of impure flint, very common in mountain limestone, and sometimes found in the chalk, are called chert.

Certain hot springs and geysers, like those in Iceland and New Zealand, contain in solution large quantities of silica in combination with soda, lime, magnesia and iron.

When these heated solutions cool, they deposit silicates on any substance with which they come into contact; so that animal or vegetable tissues immersed in these waters may become petrified in their deepest fibres.

The banks of Lake Taupo, says Mr. Martin, who has lately visited it, are perforated with thousands of springs which form cooking-places for the Maoris. Every hut has its natural boiler in which baskets of potatoes, fish or other food are suspended until ready for table; while, over some of the hottest portions of the ground, large slabs of stone are placed, on which, covered by moist grass, bread is baked.

Passing through this district, Mr. Martin came upon a spacious plateau of silica which reverberated beneath his tread. The temperature of its surface was over 100° F.; and a large opening revealed the fact that he was walking on a crust of unknown strength and thickness over a huge basin of boiling water. Numerous smaller springs, supersaturated solutions of silica, formed very beautiful incrustations in a short time, and articles dipped into them were speedily covered with a soft and delicate deposit resembling hoar-frost. Taking a bath in a neighbouring pool, in a few minutes one's skin was covered with a fine silicious coating of exquisite smoothness.

It has been ascertained by analysis that the silicates contained in these waters vary in quantity from 71 grains in a gallon to 3 grains in a gallon.

But the formation of Flint, which is pure silex and not a salt of silica, cannot be explained quite so easily. Because, in the first place, silica itself is absolutely insoluble in water; and in the next place silicification is not a constant but an intermittent phenomenon.

Flint occurs in irregular but for the most part independent nodules that vary in size from particles of microscopic minuteness to masses three feet in diameter. A careful examination shows that they consist, in most cases, of silicified sponges, corals, sea-urchins, or molluscs; while in other cases the silicious material is aggregated round a nucleus of animal or vegetable structure.

Chert, however, consists of a silicious agglutination, either of particles of sand as in cretaceous beds, or of minute silicified organisms, as in calcareous rocks.

Now, as on the one hand, flint nodules, no matter what their basis, are found arranged in definite layers, which correspond with the bedding of the chalk but which are separated from one another by intervals of entirely cretaceous material; so on the other hand, chert, however formed, and whether in broad or narrow bands, alternates with beds of limestone.

In this striking way the problem emerges, that whereas in ocean-waters the materials both for silicification and for calcification are always present, these processes go on not coincidently, but in an alternating and highly irregular manner and so assuredly depend on some "reciprocating" oscillatory causal agency that favours this process as it swings in one direction, and that process as it swings in the other direction.

The materials for silicification exist abundantly in the sea; but some way must be shown by which silica, insoluble in water, can be removed from its salts and deposited in organic tissues. Now, solutions of silicates, in the presence of some acids, and notably in the presence of hydrochloric and carbonic acids, throw down a gelatinous hydrate of silica which dissolves in excess of the acid; and by dialysis through organic membranes a pure soluble silicic acid is left, which undergoes a spontaneous decomposition into a colloidal silica.

At the bottom of the sea, then, we have the constant presence of salts of silica, of animals and, consequently, of carbonic acid, of hydrochloric acid, and of dialysing membranes. Yet silicification is not constant but intermittent.

The materials for calcification also exist abundantly in the ocean: lime, carbonic acid, and decaying organic structures; and yet calcification, too, is irregularly intermittent.

During the third cruise of H.M.S. Porcupine, a number of specimens of salt-water were procured for analysis; and in every place where water was taken from the surface, water was taken also from the bottom of the sea. Three examples are here given of the analytical result, premising that the total average quantity of solids in solution was 4,000 grams in 100,000 c.c. of water; and in these 4,000 grams the amount of silica was so little as to vary from 2 grams to one-tenth of a gram.

		Sp. gr.	Temperature Fahrenheit.	Grams in 100,000 c.c. of water.
1.	Surface of sea	1.0268	52.6	2.10
	Bottom, 767 fathoms ...	1.0268	41.4	1.10
2.	Surface.....................	1.0266	52.5	0.75
	Bottom, 363 fathoms ...	1.0268	31.4	0.10
3.	Surface.....................	1.0265	49.7	0.30
	Bottom, 640 fathoms ...	1.0262	26.6	0.10

Now, whether the sea obtains its silicates from the felspathic rocks that break its billows, or from the diatomaceous organisms that perish in its depths, we should have expected to find, if there were any difference at all, a larger amount of silicious matter at the bottom of the sea than at the top. The reverse is the case, however, in the instances just quoted. We see, too, that as the specific gravity is practically uniform, and unaffected by depth, the only concomitant variations are those of the temperature of the water and the quantity of silica in solution.

But if a falling temperature facilitates the deposition of silica, it acts, as regards lime, in a manner precisely the contrary. For the chief factors in calcification are calcium oxide (lime) and carbonic acid, and it is well known that both of these substances are more soluble in cold than in hot water.*

Have we not found then, at last, the unrhythmical but reciprocating cause of which we have been in quest? When the sea is in any manner chilled, silica tends to be thrown down and lime to be taken up; and when the sea is in any manner warmed, then lime is deposited and silicates are dissolved.

II.—FLINT IMPLEMENTS.

FLINT was highly prized by aboriginal men. It possesses many most valuable properties. Its edge can be made so fine and keen that, for shaving hair, modern savages have preferred it to razors made of steel. It is practically indestructible. It is of a wonderful hardness. Stones on which bronze produces no effect, can be cut with flint. Even granite can be carved with a flint tool ; and Captain Cook found that the New Zealanders were able to make holes through glass with their silicious drills.

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* One volume of water at 32° F. dissolves 1.797 volumes of carbonic acid, whilst at 68° F. only 0.901 volume is absolved at the atmospheric pressure.

The readiest natural instrument was a stone, such as a monkey uses in cracking a nut. The simplest artificial stone implement was made by splitting, with a single blow, a flint pebble. By this means a cutting edge was obtained with the least amount of trouble and skill. The next advance was a weapon wrought by knocking off splinters from the small end of a massive egg-shaped nodule, so as to produce a rude semblance of a point.

Later artificers were able, by a series of well designed and dexterous blows to strike off from a piece of flint, a number of shapely flakes, suitable for implements. When this had been accomplished, what remained of the nodule was its useless centre. This is called a "core," and the presence in any place of such cores, if they are unweathered and unrolled, indicates the site of an ancient manufactory of flint implements.

In some cases the preliminary chippings were so well planned that the final blow both completed the weapon and separated it from the nodule. It was thus ready for use, as a knife, spear-head or arrow-tip, without further treatment. In other cases, flakes were subsequently trimmed to serve as awls, graving-tools, scrapers and drills.

But to strike off flakes from flint is no easy thing. Indeed, Sir John Lubbock was told by a gun-flint maker that it took him two years to learn the art, while to work the splinters into implements requires great skill and long practice.

It is quite certain that flakes and chippings of this kind cannot be produced by any of the inanimate forces of nature. Neither frost nor fire, neither the rolling of a glacier nor the violence of waves can occasion in flint the curious conchoidal fracture and the characteristic bulb of percussion that are caused by the well directed stroke of a tool-wright. So that no matter where such flakes are found, we are compelled to believe that they were the product of a skill that could have been gained only by patient perseverance.

The manufacture of long and shapely spear-points, of barbed arrow-heads, of grooved or perforated celts, and the beautiful polish which many of these weapons received, were the performance of later and more accomplished workmen.

It is easy to understand, as all incisive and durable instruments were made of silicious stones, that these were held in high esteem, and that their very name was synonymous with strength and majesty. An implement like a mace, armed with a cluster of projecting stones, was borne as a sign of authority. Curiously constructed and unserviceably large flint arrow-heads were used on occasions of state parade. The delicately wrought, sometimes massive and sometimes miniature stone axes, often found in sepulchres of the fifth century, had probably a similar, though a religious meaning. And, inasmuch as one of the Welsh names for flint is *careg dân* or charm stone, we may suppose that the original knowledge of the value of the material survived as a superstitious regard. Moreover, it is worth observing that, even after the introduction of bronze and iron, metallic weapons were made, for a long time, of the same shape and size as the old ones of stone.

Flint implements have been met with in nearly all parts of the world, and everywhere alike they bear to each other a striking general resemblance in form and workmanship. It was supposed until recently that there were no indications of a stone age in Africa. In Egypt, however, are found thin, flat, leaf-shaped knives of dark cherty flint; and near Tunis Dr. Belucci has lately discovered, both on the surface and at a depth varying from a foot to more than two feet below it, flint flakes and cores.

In places where flint does not occur naturally and could not be readily obtained from a distance, weapons were made of other silicious stones. Obsidian was much used in Mexico. Arrow-heads and scrapers, made of quartzite and jasper, have been dug up in Cape Town eighteen feet below the surface; and similar implements have been met with near Graham's Town.

An interesting discovery has lately been made in Russia, by M. Shaposhnikoff. In the district of Valdaï, where a forest had been cut down, and the wind had denuded the sand of the subsoil, great numbers of stone implements were brought to light, such as knives and saws, of very perfect workmanship. But there were also similar implements in miniature made of the finest kind of flint, as well as ornamental designs in stone.

In other parts of the world weapons have been found made of chert, felstone, basalt, porphyry, and even of slate. Indeed for some purposes, flint is not the best tool. It has been found by experiment that granite is better sculptured by tough stones like diorite; and this corresponds with the practice of the present time, since the steel implements used for cutting granite are of a much softer temper than those employed for cutting sandstone. The great stone of Montezuma, which was transported to the city of Mexico by ten thousand Indians, is said to have been sculptured by thirty workmen with stone axes.

Silicious implements, as well as material for their manufacture, must often have been carried long distances. Thus, axes of jade are found in Italy, France, Germany, and England; but the substance itself is not known to occur in Europe.

Flint does not exist naturally in the district of Lake Constance, yet it is met with in such quantities on the shore of the Ueberlinger See, that the inhabitants from time immemorial have drawn their supplies of flint from this store without its having become exhausted. It was the great abundance of this material, which had evidently been brought there by man, that first led M. Ullersberger to the discovery of the ancient Lake Dwellings.

In like manner, no flint occurs native in the neighbourhood of Blackstone Edge; yet the surrounding hills abound with implements and fragments of this substance, so much so as to have influenced even the nomenclature of the locality.

Before leaving this division of our subject it may be well to lay down four propositions as cardinal guides in the investigation of the relics of a Stone Age.

1.—The fact that a flint implement is unpolished does not of itself prove the implement to be palæolithic rather than neolithic. Because, though a high degree of delicate and skilful workmanship shows that a stone weapon belongs to a comparatively recent period, the converse does not hold good. In the latter days of the stone age, as well as in the beginning, there were bad and careless workmen; whilst it is evident that during the pressure of war, or under the exigencies of the chase, rapid production must often have been of greater importance than elegance of style. Moreover, as the glory of the stone age declined, when the remnants of a despised and inferior race were hunted on the hills, or were shut out, on cold moors, to perish from want and exposure through slow centuries, the perfection of art would be lost, the trade in silicious material would cease, and the last manufacture of flint implements might well become the worst and rudest of all.

2.—It is the fact that the stone age continued all through the metallic ages, and has not, even yet, altogether come to an end. If, on the one hand, we discover wrought flints buried under accumulated strata, where they lie in undisturbed juxtaposition with the remains of animals that have long since become extinct; on the other hand, in all parts of Europe we find implements of stone associated with Roman coins. Stone axes are common in Scandinavian tombs of the fifth century; flint flakes are found in Saxon interments as late, probably, as the tenth century; and flint implements are being used, by some peoples, even in our own times.

3.—So that wherever wrought flints or stone weapons are discovered, *their age must be determined solely by their horizon*,—that is, by a consideration of their site and associations.

4.—And, lastly, wherever such implements are met with, no matter what their estimated age, it is certain that they were produced by beings, human, or perhaps pre-human, who learned to do so by long and patient practice.

III.—THE GLACIAL THEORY.

THERE is no more any doubt as to the former occurrence of periods of European glaciation, though the scientific world is still somewhat divided as to their cause and extent. We may take Prof. Dawkins and Prof. Haughton as representing the more moderate view, and Prof. Ramsay and Mr. Croll as the advocates of extreme opinions.

Prof. Dawkins, in his "Cave Hunting," does, indeed, freely admit that "there have been two periods of glaciation in Britain. "The first was a time when a continuous ice-sheet covered the "whole country." Traces of this period, in the shape of a true "till," a tough clay produced by glacial action, are to be met with at the Little Orme's Head, and in South Lancashire. "This was "succeeded by a period of depression beneath the sea"—others would say, by a rising of the sea over the land, in consequence of the melting of immense masses of ice—"to a height of 1,300 feet, "when, from the pre-existing glacial detritus, were washed the "shingle and sand which constitute the middle drift."

The second glaciation, according to Prof. Dawkins, took place after "a re-elevation of the land"—others would say, after the sea had been again withdrawn—"when glaciers were formed which "occupied isolated areas, but did not compose a continuous "sheet." Traces of this period are to be found in the boulder-clay that exists so abundantly in East Lancashire. Prof. Dawkins further says, in the work already cited, that "Pleistocene mammals, "including man, occupied Europe before the first of these two glacial periods, and inhabited Britain during the second."

He now speaks, however, in a lately published article, of a *threefold* arrangement of the glacial strata of Pleistocene times; while recent discoveries have led him to conclude that early British man was probably pre-glacial.

Now, there are two essential requisites of an ice age; first, *great heat to raise vapour*, and second, *great cold*, as on high mountains, *to condense it.* Altitude of land, then, must always be a likely factor in the production of an ice age, but there are others of more importance. "The climate," says Prof. Dawkins, "must "have been arctic in its severity during this period of glaciation, "and this may have been partially due to the fact of the land "standing at a higher level above the sea, and being lifted up "into the colder regions of the atmosphere. *It cannot however* "*be wholly so explained*, since it was the culmination of a series of "changes by which the tropical climate of the Eocene passed "into the warm Meiocene and the temperate Pleiocene climates."

The one source of heat is the sun, the chief occasion of cold is radiation; what we have to discover, then, is some reciprocating causal action that shall both produce the heat and permit the cold.

It is well known that the earth's orbit undergoes gradual changes, becoming at one time almost circular, and at another considerably eccentric. So much is this the case, that the difference between her *nearest* distance *to* the sun, and her *farthest* distance *from* the sun may be upwards of fourteen millions of miles (14,368,200).

This change in the eccentricity of the earth's orbit may affect the climate in two ways; 1.—By increasing or diminishing the mean annual amount of sun-heat; or, 2.—By increasing or diminishing the difference between summer and winter temperatures.

1.—The total quantity of sun-heat received by the earth in a year is inversely proportional to the minor axis of her orbit, so that the lessened amount of heat occasioned by her maximum eccentricity would be only as 997 to 1,000; or, in other words, the sun-heat which is now sufficient to melt 100 feet of ice would then melt 3½ inches less. It must not be forgotten, however, that the sum of constantly recurring, though minute, increments, may reach at length overwhelming proportions.

Prof. Haughton shows that at a North Latitude of 70° the greatest possible lowering of the mean secular temperature occasioned by the maximum eccentricity would be 4.985° F. But he is of opinion that a diminution of 4° F. in the temperature of the summer months of Norway, would place one-fourth of the surface of that country within the snow-line, and would pour glaciers into the head of every fiord that opens on the western coast. As the figures he gives are those of *mean temperatures*, it is easy to understand that by diminished annual sun-heat alone, as occasioned by terrestrial eccentricity, there might come upon countries north of 50° lat. a very considerable refrigeration.

2.—A change in the eccentricity of the earth's orbit may influence the climate by *increasing the difference between summer and winter temperatures.* A period of maximum terrestrial eccentricity may last for 100,000 or 200,000 years, and meanwhile, in consequence of the precession of the equinoxes, which effects a revolution of the equinoctial point upon the ecliptic once in 21,000 years, it would occur many times that our northern winter would happen in aphelion, or when the earth is farthest from the sun. It is true that, in accordance with Kepler's law,* the northern and southern hemispheres receive equal quantities of sun-heat in summer, and equal, *though different*, quantities of sun-heat in winter, whatever may be the eccentricity of the earth's orbit; because greater proximity of the sun is compensated by swifter motion of the earth. But *quantity of heat* is not the same thing as *intensity*, as may be understood by considering that from May 10th till August 3rd, the quantity of heat received at the north pole from the sun, in consequence of his remaining continually above the horizon, is actually greater than the quantity received, during the same eighty-five days, at the equator. The difference between quantity and intensity is also shown by the familiar fact that however much heat ice may receive, its temperature is not raised above 32° F.

Moreover, in the case we are supposing, with a maximum terrestrial eccentricity and the northern winter in aphelion, the total sun-heat then received would be distributed over a greater lapse of time.

Our present winter is nearly 8 days shorter than our summer; but at the superior limit of eccentricity the winters of aphelion would be 36 days longer than the summers. The result of this lengthened hybernation would be a greater accumulation of northern snow which a short summer, even though a hot one, would be quite unable to melt. For the solar rays that fall on snow or ice are to a great extent reflected back into space. It has been found that where the land is covered with snow, even the summer temperature seldom rises above the freezing point, as the air cannot be warmed by the sun as quickly as it is cooled by radiation to ice, while the heat so parted with becomes latent and disappears in the mechanical work of liquefaction. And it has been observed at the antarctic continent, where a minor glaciation is at present in progress, that the summer weather consists of a succession of snow-storms and fogs.

Other effects would follow. The *difference* of temperature between the equatorial and the polar regions would be greater on the northern than on the southern hemisphere;† and as a consequence, the aerial currents of the northern hemisphere would be stronger than those of the southern, because strength of wind is due to difference of temperature; and this augmented force would be most operative in the trade winds.

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* The *radii vectores* of the planets describe equal areas in equal times.

† At present the mean annual temperature at the equator is 80.1° F.; at 60° North Latitude it is 29.3° F.; and at 60° South Latitude it is 35.3° F. Thus the difference referred to is, at present, upwards of one-seventh greater in the northern than in the southern hemisphere. In the case supposed the difference would be more considerable.

The North East Trades, then, being stronger than the South East Trades, would blow across the equator; and the line separating them would therefore be at some distance to the south of the equator.

As the currents of the ocean are due to the prevailing winds, the equatorial waters which are driven from east to west, would also, in the case supposed, be impelled more to the southern than to the northern hemisphere.

What happens at present, is as follows. The equatorial current of the Atlantic, on approaching the American coast, strikes against the wedge-like projection of Cape St. Roque and there bifurcates, one portion of the current being deflected to the south and the other to the north. It is this northern portion which becomes what is called the Gulf Stream. The tepid current of the Gulf Stream moving northwards, ultimately gains admission to the arctic ocean; but in its course it retains the rotational velocity of the equator and is thereby pressed upon the western shores of Europe and Spitzbergen, greatly modifying the winter climate of those countries. Indeed, the total quantity of heat conveyed by the Gulf Stream is nearly equal to one half of the sun-heat received by the arctic regions. Further, the entrance of the Gulf Stream into the arctic circle necessarily produces, on hydrodynamic principles, an equal and opposite counter current. This cold stream, known as the Labrador Current, moving down from the pole, is caught, in consequence of the earth's rotation, by the east coast of North America, which receives its chilling influence as far as Cape Cod.

Quite other things would befall in the case we are supposing, for the equatorial current of the Atlantic would reach the American continent *south* of the projection of Cape St. Roque, and striking obliquely against the Brazilian coast would be altogether deflected into the southern ocean. *The Gulf Stream, therefore, would not exist;* and the waters which constitute it would carry all their heat into the already warm southern regions, whose tropics would receive nearly double their present amount of warm water entirely at the expense of the northern hemisphere, while the temperature of the English winter would become colder by more than 25° F. *And the Labrador Current would not exist;* and its cold waters would remain, to be entirely frozen within the Arctic Circle and to aggravate that difference of temperature already considered.

These, then, are the chief reasons for believing that in the varying eccentricity of the earth's orbit, combined with the equinoctial precession, lies the cause of recurrent glacial periods.

We have seen that it is 1, a *causa vera*, or a cause in actual existence and operation. 2. It is an efficient cause, occasioning a certain measurable change of climate. 3. It is a reciprocating cause, producing heat by one sweep of its power, and cold by another. 4. It is a prime or initial cause, standing first in a linked series of causal agencies. And 5, it is a cumulative or accelerating cause, bringing about its results, not all at once, but by the gradual sum of a multitude of increments.

We may suppose, therefore, that whenever the eccentricity of the earth's orbit approached its superior limit, there arose conditions *favourable to the occurrence of glacial periods* lasting for thousands of years, alternated with equally prolonged periods of genial climate when northern winters happened in perihelion. When the cold was at its greatest, arctic animals like the musk-sheep and the reindeer would range down to the Mediterranean Sea; and when the cold was at its least, the spotted hyæna, the hippopotamus, and other tropical animals would roam to the northern shores of Europe. Thus it is that the bones of creatures of such opposite fauna are sometimes found in the same cave; and that arctic as well as tropical shells and plant-remains occur in alternating beds of the same locality.

Moreover, according to the theory, the greatest oscillations of sea level would take place during the severest part of the glacial epoch, when the eccentrcity of the earth's orbit would be at its highest value. These oscillations would gradually diminish in amplitude as the climate gradually became less severe. Now, as a matter of fact, the great subsidence of land as well as its great elevation, or continental ice-period, occurred during the earlier and more severe part of the last glacial epoch; and as the climate grew warmer these changes of level became smaller, till, as Mr. Croll says, we find them terminating in our submerged forests on the one hand, and our twenty-five-foot raised beach on the other.

It is of course difficult to say when the first ice age took place, but there is strong evidence to show that a severe glaciation occurred even in Palæozoic times. Along the western margin of Sutherland and Ross the Laurentian gneiss presents itself in the form of bosses, hummocks and ridges, which suggest the effects of moving ice; and these mammillations are accompanied by the smoothing, polishing and striation which tell unmistakeably of glacial action. That these appearances were not recently produced is shown by the fact that Prof. Geikie, confirmed by Prof. Ramsay, was able to trace the rounded surfaces of the Laurentian gneiss passing distinctly beneath the overlying Cambrian rocks.

To the period of eccentricity, however, which occurred 2,500,000 years ago are referred the *glacial possibilities* of the

Eocene age; those of the Meiocene age are assigned to the period which occurred 850,000 years ago; while the severe glaciation of the Pleiocene age occurred within the limits of a period which began 240,000 years ago, lasted for 160,000 years, and came to an end about 80,000 years ago. At present we are receding from glacial conditions; the earth's eccentricity is diminishing, and will continue to decrease for the next 23,900 years. [*See Plate.*]

IV.—FLINT-WORKERS.

We are now in a position to consider the way in which the various flint-workers were related to the last glaciation of Europe.

Between recurring glacial periods climate grows equable and temperate, and remains so during a great lapse of time. It is then that animal and vegetable species become fixed, and that fixed species grow more and more specialised as their equilibrium with their environment is established. It is true that individual variation still goes on. Even to-day the amount of measurable variation reaches the extent of from 10 to 20 per cent. of the average dimensions, and such variations occur not only in one part of the body, they take place concomitantly in all parts. But when external conditions do not change, or change very slowly, these individuals derive no benefit from their variation. On the contrary, they are steadily weeded out by the operation of the law that organisms not in equilibrium with their environment must perish.

But during a glacial epoch, when alternations from a cold to a warm climate happen every 10,000 or 12,000 years, individuals capable of varying would have favourable variations preserved, and new species would arise; while species whose peculiarities had become fixed, or aberrant, or extreme, would be very liable to destruction.

At the middle, then, and at the close of any glacial epoch we must expect to find two things,—the disappearance of some animals and the advent of others.

This will assuredly have been the case with the precursors of man. When the Eocene cold had passed away; while Britain was still connected by dry land with America, Asia, and Africa; these ancestral forms left their warm arboreal retreats and spread over the western plains of Europe.

The flints found in Mid-meiocene strata by the Abbé Bourgeois are very different from the palæolithic implements of the drift. They were fashioned in the rudest manner by some unknown beings, the Archæolithic Race, who indeed were not men, for no land mammal of that period is still existent. All have changed. " Man," that is, man as we know him, " the most highly specialised " of all creatures, had no place " says Prof. Dawkins, " in a fauna " which is conspicuous by the absence of all the mammalia now " associated with him."

But though the exact form and structure of these pre-men are, at present, only conjectural, we may reasonably consider that during their prolonged environment by an equable climate, newly developed bodily characteristics would tend to become fixed ; but at the same time an intellectual growth would be stimulated by an increased resort to flesh-eating and by the continual struggle for existence that is due to a rivalry for food, and to ceaseless efforts to escape carnivorous foes. The climatal uniformity, however, was interrupted by the Meiocene eccentricity, during which Europe was cut off from America, and further changes in their structure became possible, if not necessary.

Of all the mammals that inhabited Europe in the early Pleiocene age, the hippopotamus is the only survivor. We are, therefore, compelled to believe that man's ancestors were still pre-human. But when they had been sifted and selected by the climatal rigours which introduced this era, and when favourable varieties had become established during a long subsequent lapse of more even temperature, we are prepared to find that ere its close, before the occurrence of the last glaciation, they had appeared in Europe with the characteristics that we recognise in man.

The latter portion of the Pleiocene is now called the Pleistocene age ; and this age Prof. Dawkins has divided into Early, Mid and Late Pleistocene, and has founded his division on the presence or absence of animals more or less arctic. As a method of arrangement this seems to be somewhat uncertain ; because there must necessarily have been a considerable zoological overlap, and because, during the last glacial epoch, which the Pleistocene age includes, there were several alternations of arctic and genial climate. Indeed Prof. Dawkins himself, in commenting on the fact that flint implements are often found associated in the same cave with arctic and with tropical animals, says, " it must not be " supposed that the southern animals migrated from the Mediter- " ranean area as far north as Yorkshire, and the northern as far " south as the Mediterranean, *in the same year. There were* " *secular changes of climate.*"

It is for such reasons as these that, for our present purpose, we may venture to base the triple division of the Pleistocene period on the stages of the last European glaciation.

1.—Early Pleistocene, then, is properly that concluding portion of the Pleiocene age which runs up to the commencement of the corresponding glacial epoch. Temperate animals were appearing in place of tropical ones, but arctic mammalia had not yet arrived in Europe. Flints relating to this period have been found in France, and recently in our own country.

2.—Mid Pleistocene covers that lapse of time which intervened between the outset of the glacial epoch and the period of greatest cold, which was reached about 210,000 years ago. Tropical animals had almost disappeared from Europe, arctic animals had begun to arrive, and this country was covered with ice.

3.—Late Pleistocene embraces the remaining portion of the glacial epoch, when Europe was occupied by arctic animals in full force. At its close, Britain was, for the first time, separated from the continent, and was finally submerged to such an extent as to become a cluster of islands.

The earliest sign of man in Britain was discovered by Prof. Dawkins, who witnessed the finding of a palæolithic flint flake in the deeper brick-earths of Crayford, in the valley of the lower Thames. And since then Mr. Flaxman Spurrell has found, in the same strata, a multitude of fresh-looking, unrolled flakes, a number of cores, and several stones that had apparently been employed as hammers for dressing the flints—all the workmanship of that Palæolithic race whose Early Pleistocene, or pre-glacial relations we must now consider.

South of a line drawn from Bristol to the Wash, and over a region extending through Spain, Italy, and Greece, to Asia Minor and the whole of India, are found, in ancient river gravels, unpolished and somewhat clumsily made flint implements, massive and pear-shaped, with the smaller end adapted for cutting and the larger fitted for holding in the hand. There is no sign of hafted weapons; there had not dawned the idea or the power of fixing them to handles; and, consequently, there were no spears or arrows.

At the time when these tools were made, Britain had not been severed from the continent, and their possessors hunted on the banks of the Thames when that river joined its waters to those of the Elbe and the Rhine, rolled in a confluent stream over the vast plain now covered by the German ocean, and emptied itself into the sea at the latitude of the Shetland Isles.

The Palæolithic or River Drift Race belonged to a tropical fauna and their unweathered implements are seen in stratified association with the undisturbed bones of the hippopotamus, the big-nosed rhinoceros, the spotted hyæna, and the lion. These animals, unable to live in a cold climate, were all destroyed by the Mid-Pleistocene glaciation to which even man himself, long successful in resistance, finally succumbed.

A diagram of the Crayford beds, on the following page, shows the stratum in which worked flints are found. *Though the beds are composed of sand and gravel, they contain no foreign stones.* The men of this horizon were pre-glacial, and their doom was sealed. Recurrent seasons grew progressively colder; tropical animals perished, one species after another; a temperate fauna flourished intermittently; and at last arctic beasts like the polar bear, the pouched marmot, and the musk-sheep inherited the land.

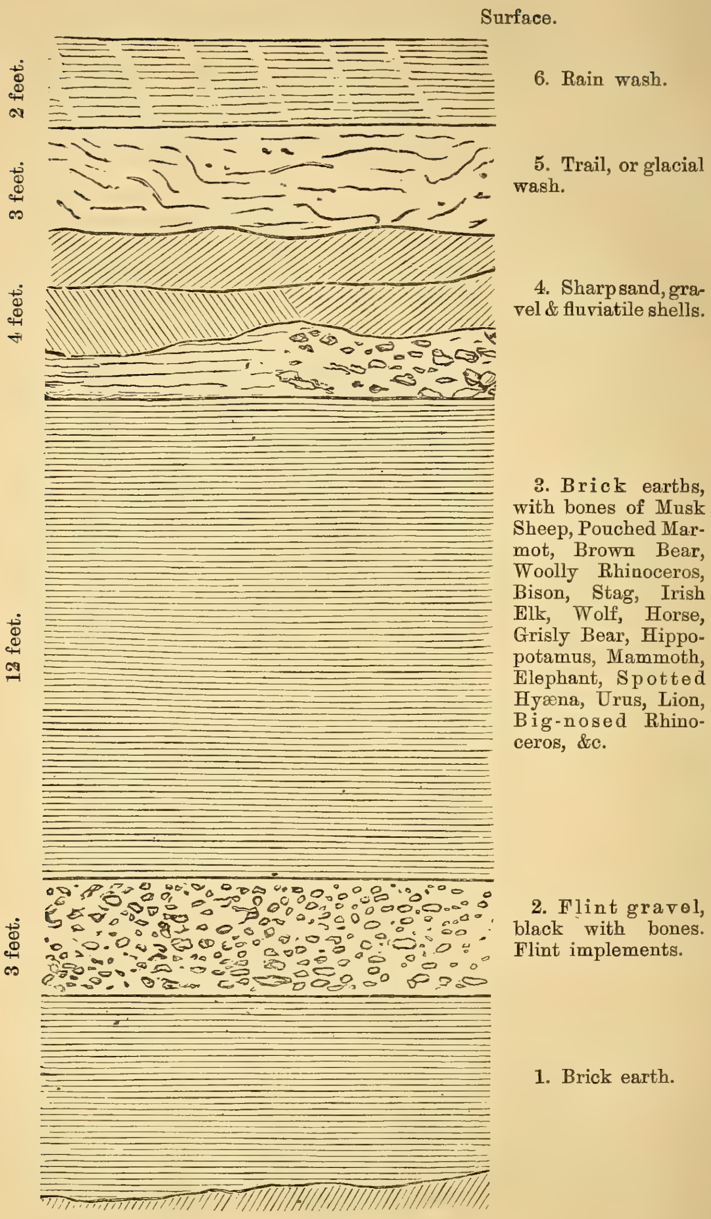
For a time Palæolithic man struggled on, and lived to be environed by some of these new-coming creatures. But it would seem that he never altered the fashion of his weapons; he continued to make them of the same type as those of his contemporaries in India and southern Europe; he was unable to adapt himself to glacial conditions; and at length he was driven away, never to return.

One of the subsequent glacial periods is indicated on the diagram in stratum No. 5, by what is called a trail, or ice-wash. This is a mixture of clay, brick-earth, and gravel, irregularly twisted and folded. It contains foreign pebbles, some of which are embedded with their long axes vertical. In one place is an "angular lump of clay torn from the Eocene beds, more than 150 "yards distant. It had evidently been deposited while it was "frozen, since it had suffered no abrasion in the course of its "transport." Mr. Spurrell has observed many similar examples.

What became of Palæolithic man is quite unknown; no bodily remains have revealed to us his structure, and he cannot be referred to any branch of the human race now living. Possibly in the south of Europe, perhaps on the fringes of wide-reaching ice-fields, he was undergoing a rapid evolution. For we meet now with the interglacial Cave Dwellers, the Mesolithic race of the late Pleistocene period, and a distinct advance in culture becomes apparent.

The cold was yet severe. Norway, Sweden, Denmark and the east of Europe were probably still glaciated, as no Palæolithic or Mesolithic weapon has been found in those countries. Glaciers were disappearing from Britain, but reindeer were abundant; and as this country was not yet separated from Africa, it was still visited during genial interglacial periods, by the hippopotamus, rhinoceros, elephant and machairodus.

The flint implements of Mesolithic man were more varied than those of his predecessors, and included awls, saws and lance-heads. He did not polish them, though polishing was practised on tools made of bone. He constructed harpoons of reindeer-horn, but made no arrows till quite late, and used no pottery.


Surface.
2 feet.
6. Rain wash.
3 feet.
5. Trail, or glacial wash.
4 feet.
4. Sharp sand, gravel & fluviatile shells.
12 feet.
3. Brick earths, with bones of Musk Sheep, Pouched Marmot, Brown Bear, Woolly Rhinoceros, Bison, Stag, Irish Elk, Wolf, Horse, Grisly Bear, Hippopotamus, Mammoth, Elephant, Spotted Hyæna, Urus, Lion, Big-nosed Rhinoceros, &c.
3 feet.
2. Flint gravel, black with bones. Flint implements.
1. Brick earth.

His cerebral powers were undergoing great stimulation, and an extraordinary artistic faculty became developed. We find similar unexpected tastes in the bower-bird who builds and adorns a great hall of public assembly, and in the garden-bird who lays out an ornamental parterre.

To have produced such evolution as this, there must have been three favouring circumstances.

1.—Something to evoke cerebral activity. This we may look for in the rivalry of the chase, in a certain emulation in the practice of their simple arts, and doubtless in the springing up of those claims and restraints that make the beginnings of society.

2.—Abundance of food to sustain cerebral activity; and food, like flesh or grain, of a stimulating kind.

3.—Leisure for the employment of cerebral activity. And leisure means two things; first that the abundant food was easily obtained, and second that there was security from personal danger. The days were not wholly spent either in hunting prey or avoiding foes. At last, too, climatal rigours had come to man's aid, and had scared away many of his formidable carnivorous enemies, and he had learned to escape from the remainder in the shelter of a cave.

His wonderful drawings, scratched on pieces of bone or ivory, show us the animals by which he was surrounded and in which he was most interested. We find him hunting the urus [*See Plate, fig.* 1], the mammoth, the reindeer, and a small horse [*See Plate, fig.* 3] with a hog-mane and a large head; and we see pictures of the seal, the whale and the cave-bear [*See Plate, fig.* 2].

Above all, he reveals to us himself [*See Plate, fig.* 1]: his body covered with long hair; his calf and thigh greatly developed; never using the arrow, but smiting with a spear the monsters on which he fed. Hurling the javelin of flint and the harpoon of horn, he was able to take both birds and fish. Though it would seem that he made clothing of skins, he usually represents himself as entirely naked.

We have also a singular portrait of the woman of the period. She was remarkably differentiated from the man. She was short, with little hair, and with slender limbs and extremities; so that whatever may have been her duties, she did not join in the chase, but had already become a domesticated animal.

It is note-worthy that the Bushmen of South Africa are natural artists, though their brains weigh only 33 ounces, as compared with the 44 ounces of the Negro, and the 49 ounces of the European. Dr. Mann thus describes the method of a Bushboy who had much skill in drawing animal figures. "He began by "jotting down upon paper a number of isolated points, which "presented no connection to the uninitiated eye, but looked like "the stars scattered promiscuously in the firmament. Having "with much deliberation satisfied himself of the sufficiency of "these dots, he forthwith began to run a free, bold line from one "to the other, and as he did so, the form of an animal, horse, "buffalo, antelope, gradually developed itself. He said that this "was the plan which was invariably followed by his tribe in "making their clever pictures."

Mesolithic men, with minds of this order, sitting at the entrance of a cave and watching the stars go by, would soon call the constellations by name. For our parts, we may see very little of a bear in Ursa Major, and not much of a man in Orion. But how easily they would fill in the outlines that our imagination is unable to complete, and behold at once a hunter, a wolf, or a dragon.

It is generally believed that the Cave Man's lineal descendants are the modern Eskimo. They use corresponding weapons, fashion their flints in like manner, hunt kindred animals, leave round their camping ground the same sort of relics, and possess a similar artistic faculty.

Mr. Galton says, "One Eskimo drew from memory a chart of "the region over which he had, at one time or another, gone in "his canoe. It extended over a distance, in a straight line, of "more than 1,100 English miles, the coast being so indented by "arms of the sea that its real length is six times as great. On "comparing this rough Eskimo outline with the Admiralty Chart "of 1870, their accordance is remarkable. I have seen many "route-maps made by travellers in past years, and I have never "known of any traveller in Africa, Asia, or Australia, who, being "unprovided with surveying instruments, and trusting to his "memory alone, has produced a chart comparable in extent and "accuracy to that of this barbarous Eskimo."

And now the Glacial Epoch and the ancient stone age were together drawing to a close. Those men whose bodily structure and habits had become fixed would be compelled, on pain of extinction, to follow the reindeer in his retreat towards the arctic circle, where, indeed, they are still associated, reindeer and Eskimo.

Others, becoming adapted to an altered environment, may have remained behind, surviving the vast changes, both in climate and in the distribution of land and water, that now took place. Africa in the south, as already America in the north, was severed from Europe, and Greenland, Ireland, and England became insulated.

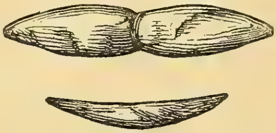
As the land continued to sink, or the waters to rise, any remnants of the Mesolithic Race must have been left stranded, as it were, on a British Archipelago. Cut off, in many cases, from chalk-districts, they must have manufactured weapons from the flints of the drift, and even from the chert; and as the supply grew gradually scarcer and the material more precious, their implements would be made progressively smaller. Acquiring, in time, a considerable skill, they would make simple arrow-tips, and delicate fish-throttles, and may have struggled for ages against adverse circumstances only to be slain at last by the polished battle axes and barbed arrows of Neolithic troops.

And the question arises whether such remnants constituted the feeble folk who camped and clustered on the summits of hills, in various parts of England, that had not been submerged.

On some of the shoulders, for instance, of the Pennine range, of an altitude of not less than perhaps 1,000 feet, under layers consisting of about twelve inches of peat, and, beneath this, of about four inches of *peaty clay*; in a grey, sandy subsoil, full of carbonaceous markings of rootlets and silicious remains of grass, the present writer has dug up a number of flakes, cores and chippings. A large proportion of the latter exhibit some part of the original surface of the flint nodule, and this is, in nearly every instance, pebbled or water-worn; showing that the nodule was not obtained directly from the chalk. Whenever, in a suitable place, the grey subsoil was carefully uncovered, implements and fragments of flint alone were found in its lower portion, but flint mingled with chert fragments in its upper portion; indicating that chert was resorted to as flint became increasingly scarce. Not one of the implements, in the slightest degree, is polished. The very floor on which these ancient tool-wrights sat, the fire by which they were warmed and the iron pyrites they used to kindle it, the reddle which stained their bodies, and all the waste of their manufacture, have been laid bare. Hammer-stones, cores, flakes, scrapers, arrow-tips, spear-tips, all of a small size, as well as minute implements such as awls, gravers, perhaps tattooing instruments, and, possibly, fish-throttles. Things such as these have been

Iron fish-gorge as now used in some parts of France.

Stone fish-throttle, found in the Swiss Lake Dwellings.



Supposed fish-throttle of flint found near Rochdale.

discovered, perfected and in every stage of imperfection. But nowhere has come to light the faintest sign of the local production of leaf-shaped or of barbed arrow-heads; and the presumption is that those beautiful ones that are sometimes, but very rarely, found on the hills we have described, were the weapons of a later people by whom this remnant of Mesolithic man was, perhaps, at last exterminated.

Whatever may be the answer to this question—and an affirmative one cannot, as yet, be given—the Neolithic or Prehistoric age is marked by the advent of a small race, about 5 feet 5 inches in stature, and of delicate features.

Sepulchral remains indicate excessive development of the muscles of the leg, and show how much time they spent in hunting or fleeing on foot. From the appearance of some of the bones we learn the nature of ills that afflicted them: inflammation, abscess, rheumatic ulceration of joints, paralysis, hip-joint disease, and water-on-the-brain.

Careful explorations have disclosed the state of their civilisation. They were entirely ignorant of the metals. Many of their stone implements were polished and of excellent workmanship. Their characteristic weapons were the arrow and the axe. They used pottery. They wove flax into tissues. Above all, they cultivated the soil, and ground their grain between two stones.

The animals they tamed, as the ox, the hog and the sheep, lead to the belief that they streamed down from Central Asia, and passed over Europe like the succeeding waves of Aryans; like the Celts, Belgæ, Greeks, Latins, and the Germanic peoples. They gave origin to the early Iberians, and are represented by the modern Basque, and though the philological researches of Prince Lucien Bonaparte have led him to call this people Non-Aryan, it may be noticed (1.) that they were acquainted with agriculture: *arya* means a husbandman, from the root *ar*, to plough; (2.) that they came from the same district as the Aryans; and (3.) that their names for certain implements bear a strong resemblance to words of the same meaning in Sanscrit. In any case, it seems to be agreed that they constituted the early Lake Dwellers of Switzerland, and were the depositors of the ancient Kjokken Möddings of Denmark. Similar lacustrine remains have been found also in Scotland and in Wales; and it is remarkable that the Welsh Lake Legends all contain the mention of *iron* as the cause of disaster to the fairies.

The relics found deep in the beds of the Swiss Lakes are especially interesting, because so well preserved. We see, for instance, that flint arrow-heads were not only bound to the shaft by cord, but were further secured by asphalt. And in this connection it is remarkable to be told by Antonio Herrera, in 1601, that the Iroquois Indians "had swords made of wood, having a "gutter in the fore-part, in which were sharp-edged flints strongly "fixed with a sort of bitumen and thread."

This Neolithic Race, then, spread over Europe; but not as far as the north of Russia and of Scandinavia; permitting the assumption that these were the only countries that still remained uninhabitable by reason of cold. For we may notice that the shell-heaps of the Danish Kjokken Möddings, which abound with flint implements and show no traces of metal, contain the bones of the Capercailzie, a bird that feeds on the buds of the pine; proving that Denmark at that time was covered with forests of fir.* And we may notice, further, that neither in these shell-heaps, nor in the relic-beds of the Lakes, have there been discovered any remains of the reindeer. So we may fairly conclude that, with the exceptions referred to, Europe was at last free from glacial conditions.

And now the arts of civilisation rapidly increased. Copper, and probably gold also, were got and wrought by stone tools. No metallic implement of any description has been found in the prehistoric copper-mines of Lake Superior. "The workings were "effected by stone hammers and wedges, specimens of which "were discovered, by the United States geologists, in great "abundance at the bottom of the pits." Stone chisels or axes, flint tools and weapons, and the remains of wooden shovels were also found. The copper was made into axes, chisels, knives, and spear-heads, entirely by the hammer, without smelting, alloy, or the use of fire. Prof. Wilson says, "I was struck when examining "these rude mauls or stone hammers, by the close resemblance "traceable between them and some which I have obtained from "ancient copper workings in North Wales." Precisely similar hammers were found by Prof. Dawkins in the ancient copper mines of Alderley Edge, and are preserved in the Owens' College Museum.

Bronze was discovered, in all probability, by the accidental fusion of ores of copper and tin, under the fires used for preparing food, or in heating stones for pot-boilers; as such stones in such situations have been found in a semi-fused condition. But for a long period bronze axes and spear-heads were cast of exactly the same shape as the old spear-heads and axes of stone.

Gold, silver and lead, all, like copper, soft and malleable metals, were early wrought. In the five tombs of Mycenæ, Dr. Schliemann found no trace of iron; but in association with arrow-heads and knives of obsidian, and with swords and lances of bronze, there were articles of lead and silver, and an enormous number of gold vessels and ornaments.

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* It is known that these were succeeded by forests of oak, which gave place, in their turn, to the present forests of birch.

Thus we see that the so-called stone age overlapped in its full strength the age of copper and of bronze. It overlapped, but to a less extent, the age of iron; and it even overlaps in some degree our own age of gunpowder and steam, for "the modern flint lance "of the Red Indian can hardly be distinguished from that found "in the most ancient British graves."

The introduction of iron heralded the approach of the Historic Age. Those nations that lived on the shores of the Mediterranean early availed themselves of the new metal, but not till long centuries had elapsed did the outer world throw aside their weapons of stone and bronze.

Herodotus says of the Ethiopians in the army of Xerxes, "they "had sharp arrows made of reeds and pointed instead of iron, "with a kind of stone used to engrave seals." If a Greek officer in command of this contingent had been slain, we may feel sure that his Ethiopian servants would have placed in his tomb flint flakes and arrow-heads.

A supposition of this kind may serve to explain difficult cases like the following. In the tumulus of Kouloba, near Kertch, a heap of sharp flints was found in association with an iron sword, gold ornaments, figures of animals and of a tiger above whose tail was written a Greek inscription. Prof. Dawkins discovered inside a Roman coffin, at Hardham, in Sussex, in a cemetery that belongs to the later portion of the Roman dominion in Britain, several flint flakes.

The propositions that we have already laid down accord with M. Keller's remark that stone weapons are an unsafe guide in determining age, though they strictly represent the stone period, because they occur in all stages of the bronze age, and are not infrequently found associated with iron weapons and instruments.

There is no doubt, says Sir John Lubbock, that in early ages stone and metal were used at the same time; the first by the poor, the second by the rich. Bronze and iron implements must always have been expensive and difficult to procure.

Cæsar testifies that all the bronze used by the Britons was obtained from abroad; and there is reason to believe that iron was also imported in the form of pigs or ingots. The Britons used rings of bronze and iron as money. It is probable that the Romans introduced into this country the practice of smelting iron, for in the time of Strabo this metal had become an article of export.

Thus, while British furnaces were instituted and controlled by the Romans; at the same time, entirely under their command were the sea and the high-roads; so that, after the Occupation, no iron would be allowed to pass into the hands of the people.

It would seem, then, that for purposes of the chase, as well as for war, those Britons who were not in Roman service may have been compelled to use flint weapons.

It is likely that of all the implements made of stone, arrow-heads would be the last to drop out of use, as being well adapted to the required end and formed of a material so abundant. Arrows are very liable to be lost, and flint would be preferred to metal which even when it could be obtained was scarce and costly.

There is little doubt, says Mr. Evans, that in the poorer and more inaccessible parts of Britain, stone continued in use for many ordinary purposes long after iron was known in the richer and more accessible districts.

Some of the northern parts of this country must have been very inaccessible; and that they were poor is shown by the fact that, with the exception of Liverpool, no British coins have ever been found in Lancashire, Cumberland and Westmoreland.

Moreover, it is possible that flint implements were used even by some of the Celtic servants of the Saxons. Mr. Evans observes that "in Saxon graves small nests of chipped flints are not "infrequent." Mr. Bateman, a most careful explorer, opened a number of Saxon barrows in Derbyshire, and in some of them found stone weapons, and, respecting one case, he remarks—"the discovery of instruments of flint with an interment of this "comparatively modern description is by no means unprecedented."

In a horned cairn, in Caithness, believed by Mr. Fergusson to be a Viking's grave, and stated in Barry's History of Orkney to have been occupied by the body of Laudver, son of Thorfin, was found a cist containing pieces of pottery and flint chips. The fight in which this chief was slain, took place not earlier than A.D. 970.

Still stranger, William of Poitiers says that at the Battle of Hastings the Anglo-Saxons fought with weapons of stone—"*et lignis imposita saxa jactant.*" In this instance the probability is that Harold, who had just suffered immense losses with the Norsemen near York, and who was compelled to make forced marches to the south to meet William of Normandy, was only too glad to strengthen his thin ranks by any Celtic or other serfs he could find, though clubs studded with sharp flints were their only arms.

As the use of stone implements continued longest in the poorer and more inaccessible parts of Britain, and as it must have been the dwellers there that longest resisted the second introduction of Christianity, it is easy to understand how these two facts became associated in the popular mind; and how the placing of flints in a grave became the symbol of pagan sepulture. This feeling survived till the time of Shakespeare.

When Ophelia, who had drowned herself, has to be buried, the grave-diggers say—"Is *she* to be buried in christian burial, "that wilfully seeks her own salvation?" "I tell thee, she is; "therefore make her grave straight." Afterwards the priest objects. Even in those days there were conscientious difficulties about interments. "Her death," says the ecclesiastic, "was "doubtful; and, but that great command o'ersways the order "she should in ground unsanctified have lodged, till the last "trumpet; for charitable prayers, shards,* flints, and pebbles "should be thrown on her."

V.—LINGUISTIC VESTIGES OF THE STONE AGE.

We have now been able to see, with considerable distinctness, that the ancestors of all nations lived in a stone age when they were unacquainted with metals, and when their implements of wood, horn, or bone were tipped and strengthened by hard substances like flint and obsidian.

As this was universally the case, it is of course to be expected that a careful examination into the languages and customs of mankind would lead to much corroborative evidence of a highly interesting nature: and perhaps even the very imperfect way in which we are able to deal with the historical and linguistic part of our subject may not be without a certain value.

Mr. E. B. Tylor, in his Early History of Mankind, says "superstition is the *standing over* of old habits into the midst of a "new and changed state of things—the retention of ancient "practices for ceremonial purposes, long after they have been "superseded for the uses of ordinary life."

Thus in ancient Egypt, in embalming, though the brain was removed by a crooked iron, the body was incised by a sharp Ethiopian stone.

Among the Guanches of Teneriffe, though iron was in common use, the bodies of the chiefs were cut open with obsidian knives.

* That is pot-sherds, or broken pieces of earthenware. With the dead were buried dead things—broken weapons, and vessels in fragments.

It is related in the Bible that Sepphôra performed circumcision with "a sharp stone" (E.V.). The Vulgate says *acutissima petra*, with a very sharp stone. The Septuagint has the word ψῆφος, which means a pebble, the Latin *calculus*; and we know that the simplest flint implements were made from pebbles or nodules. In the Hebrew the word is *tzūr* or *tzōr*, a flint; and this word is used in many other parts of the Bible, but always with the fundamental sense of hardness and sharpness or edge.

Thus it is employed in the sense of hardness in Ezekiel iii, 9, "as an adamant harder than flint;" and in Isaiah v, 28, whose "horses' hoofs shall be counted like flint."

The same word is often rendered "rock," as in Isaiah viii, 14, "for a rock of offence;" and in Isaiah li, 1, "look to the rock "whence ye are hewn."

In the sense of sharpness or edge, the same Hebrew word, flint, occurs in Psalm lxxxix, 43, "Thou hast also turned the "edge [or flint] of his sword."

In Joshua, v, 2, the English version says, "Make thee sharp "knives and circumcise the children of Israel." The Hebrew is literally "knives of flint." The Septuagint has Ποίησον σεαυτῶ μαιχαίρας πετρίνας ἐκ πέτρας ἀκροτόμου, that is, literally, "make "thee stone knives of chipped stone;" ἀκροτομέω meaning to trim or chip the point. The Vulgate is *cultros lapideos*, knives of stone.

It is noteworthy that the Septuagint records the further fact, that when Joshua (xxiv, 30) was buried, "they put with him *the* "*knives of stone*, τὰς μαχαίρας τὰς πετρίνας, with which he "circumcised the children of Israel."

It is thus clear that the early Hebrews used implements of flint for ceremonial purposes, and that flint implements were sometimes placed in the tombs of their great men. It is also clear that the Hebrew word for flint came to symbolise two ideas, hardness and sharpness.

But as all nations have passed through similar stages of progress, we ought to discover in all languages similar traces of the fact. And so we do. For obvious reasons, however, it will be necessary to confine our attention to the Indo-European, or Aryan group of tongues; and of these, more particularly Sanskrit, Greek, Latin, Celtic, and Teutonic.

Let us take first the ancient root AK to pierce. We should expect to find this connected in the first instance with stones, then with implements, and lastly with those who fashioned and used them.

In Sanskrit we have

aksh, to penetrate.
aksha, an axle, axis or pivot; that which penetrates.

Then, *as'*, to pierce.
as'an, a stone, a rock ; a missile stone.
as'ani, a missile ; the tip of a missile ; the name of a warrior tribe.

Again, *as*, to throw.
asi, a sword, a knife.
astra, a bolt or arrow ; arms in general.

Connected with these Sanskrit forms we have in Greek,
ἀκή, a point, edge.
ἀκμή, the highest point.
ἄκρος, at the top or edge.
ἄχος, a sharp pain, ache.
ὀξύς, sharp.
Βέλη ὀξέα, sharp arrows.
ἀξίνη, an axe.
ἄξων, an axle or axis.

In Latin we get
ascia, an axe.
acus, a needle.
acicula, a small pin.
acer, *acris*, sharp.
acies, the line or edge of battle.
acuere, to cut.
acidus, sour.
acor, sharpness.
acutus, sharp.

And in Anglo-Saxon and English we have
adesa, adze.
æx, axe.
ecg, edge.
ece, ache, a sharp pain.
eggian, to sharpen.
Cf. to edge or egg on ; to set teeth on edge ; edged tools.

By help of this root we can trace here, as elsewhere, a relation between the hardness of flint and its fire-producing quality.

Thus, in Sanskrit
agra, point, sharpness.
agri, fire.

And in Latin
agmen, battle.
ignis, fire.

In a different direction we find a similar example.
Sanskrit, *arani*, flint ; hard wood for rubbing into fire.
Latin, *æs*, *æris*, copper ; brass ; iron.

Gothic, *ais*, brass.
O. H. G., *ér*, brass.
A. S., *ár*, *ær*, ore, brass.
aruwe, arrow.
íren, *isen*, iron.
German, *eisen*, iron.

Another class of words, connected with the root SKA to cut, again reveals the original material of cutting instruments.

German, *kiesel*, a pebble.
A. S., *ceosel*, gravel.
Fr. *ciseau*, }
O. F., *cisel*, } a cutting instrument.
English, *chisel*, }

With the root SAK to cut, we may connect the following:

Sanskrit, *sah*, strong.
sahas, strength.
Latin, *saxum*, a stone.
secare, *sectum*, to cut.
sagitta, an arrow.
A.S.—premising that ancient roots are often found in personal names—
Seaxburg, stone of defence; the name of a queen in 618.
sæx, a knife.
seax, a short sword, from the use of which our ancestors may have been called Saxons.

But the most interesting class of words, for our purpose, as well as the most numerous, is that connected with the root SKAR or SKAL, to cut. There is a well known mutation between the consonants *r* and *l*; an interchange that is common and inevitable. Thus, the Latins had two verbs *verro* and *vello*, both signifying the same thing, to tear up. Our "star," from the A.S. *steorra*, and our "constellation" from the Lat. *stella*, both come down to us from the Sans. *stri*, to strew—as the orbs of heaven seem strewn over the firmament. And in Doomsday Book, to come nearer home, Warrington was spelled Walintune.

In connection with the roots just mentioned, we get, in Sanskrit,

Khala, a mill; a threshing-floor. Of course it will be recollected that grain was originally crushed between stones. Indeed, from this root come our words quern, corn, and grain.
Khalla, a mill; a stone for grinding drugs—a ceremonial use.

In Greek, κείρειν, to cut.
Celt. *careg*, a rock.
A. S. *gâr*, }
O. S. *gêr*, } a spear.

The Gar-Danes were a warlike tribe. The gar is a fish, so called from the resemblance of its head to a spear, as is the case with the pike and the ged or *goad;* while the hake is named from the *hooked* appearance of its jaw.

The Germans, too, may owe their designation to their having used a particular kind of spear. It is certain that the Lombards, a word contracted from Longo-bard, used a long *barta* or axe; and that the Franks and Franciscans carried a *franca* or lance, the *framea* of Tacitus, which was a slender blade for throwing, or for stabbing at close quarters, like the Zulu's assegai.

But *gâr* and *gêr* also appear as *gal* and *gel.*

Goth.	*hallus*,	a rock.
O. N.	*hallr*,	a stone.
Celt.	*callestr*, *cellt*,	a flint.
Fr.	*caillou*,	a flint.
Eng.	*celt*,	a stone implement.
Erse.	*cail*,	a spear.
Lat.	*Culter*, *Celtis*,	a knife.

The word Celts, as a national name, is the Latin Celtæ, and the Greek Κέλται, which became respectively Galli and Γάλαται. We find the same word, too, in Gaul, Galway, and Caledonia. It is not improbable that these ancient people were originally so designated from their use of some particular kind of weapon.

Pliny (vii, 56) speaks of the myth that fire was first struck out of flint by Pyrodes, son of Cilix. Here are two matters of interest. The first is that Pyrodes is the same word as our iron *pyrites*, the substance that was used with flint for this purpose by prehistoric man.

The second matter of interest is the proof, in the spelling of Cilix, that the s in silica was originally hard.

Thus from

Lat.	*cilix*,	flint, we come at once to
	calculus,	a pebble.
Gr.	χάλιξ,	a small stone, and the rubble among which pebbles are found.
	κῆλον,	an arrow.
Latin,	*calx*,	a small stone, limestone.
A. S.,	*cealc*,	the material from which flint is obtained.
English,	*chalk*,	

It is worth noticing that the Latin *calculo* means to count, our calculate, because counting was originally done by pebbles; and that the Sanskrit *kal* also means to count, while *kali* is an arrow. And all these words come from *khara*, a rock or stone.

Moreover, we have seen that in addition to the sense of sharpness or edge that we associate with flint or stone, there is also the idea of hardness or hammering power. So that we are prepared to find that the Latin *calcare* means to tread under foot, to kick, "to recalcitrate;" and that *calx* means the heel, the hammer of the foot.

And now, recollecting that χάλιξ signifies a pebble, we come, all at once, to perceive that the Greek word χαλκός contains the whole history of human progress—

χάλιξ, a pebble.
χαλκός, 1.—Originally a flint nodule, a stone implement.
2.—Copper, when first wrought.
3.—Brass or bronze, when it superseded stone.
4.—Iron, in the iron age—supplanting σίδηρος, which, from its meteoric origin, was its first name.
5.—Metals in general.
χάλυψ, 6.—Hardened steel.

So the word χαλκός being used, in the end, to designate only iron, there is left no specific name for flint in the Greek language.* While, as if no link should be wanting, χαλκηδών, or chalcedony, is a white quartz, a substance formerly much valued for making stone implements, found in Chalcedon in Asia Minor; Χαλκίς is a city in Eubæa, which derives its name from some neighbouring copper mines; and Χάλυψ signifies one of the nation of Chalybes in Pontus, famous for the working of steel.

CONCLUSION.

It is not inopportune to recall, in conclusion, that the history of language affords a striking example of the Law of Evolution. In words, as in organisms, we see the phenomena of growth, variation, competition, survival, and extinction. Having its origin in the simplest elements, having for the most part an onomatopæic foundation, or a basis of imitative sound, language is evolved by degrees into highly complex forms. It changes with a changing environment, and is never stable or at rest. The confusion of tongues is, indeed, a consequence and not the cause of the dispersion of peoples; and though a printed and widely diffused literature may greatly hinder, it cannot arrest this linguistic flux, for diversity of speech is as inevitable as diversity of life.

Every word, like a living creature, has a structure, a kindred, a pedigree; and the grammar of language resembles a scheme of natural history. Etymology is a kind of embryology; and there are verbal homologues and rudiments as well as animal ones.

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* The word κροκάλη, the sea-shore, shingle, is probably connected with root GAR, to make a noise: Sanskrit, *gharghara*, a rattling.

If fossil forms, discovered in the earth's crust, supply missing zoological links, no less do fossil words, found in archaic manuscripts and in sculptures of the past, often reveal an unexpected connection in nomenclature.

A linguistic arrangement such as that of the Indo-European tongues, is like a classification of botanical orders, and the gulf that divides the Aryan, the Turanian and the Caucasian languages is similar to that which separates mammals, birds and fishes.

But, as great unlikeness of structure points to the immense duration of animal life, so does great diversity of speech indicate the high antiquity of mankind.

How little has the coast-line altered since Cæsar landed on British shores nearly 2,000 years ago; how remote must be the period when this country, separated by no sea from Europe, was traversed by palæolithic hunters; and, as the simple arts they practised required many ages for their invention, perfection, and wide diffusion, how certain it is, that when we have gone back to those dim and distant days, we are yet far from having reached the origin of our race.

It is not a little remarkable that we owe all our knowledge of these primitive beings, to their use of an indestructible material for implements. They have left neither dwellings nor tombs, and every vestige of their bodies has vanished away. But it is, perhaps, more remarkable still, that all organic traces of a much less ancient race, of the neolithic tribes of Lancashire, have vanished likewise, though their silicious relics are found on the hill-tops every day.

Of those who lived before the palæolithic age, who wrought only with horn or wood, we may remain for ever ignorant. But by the flints that strew the ground, we can discern, however faintly, the path ancestral man has trod. We can estimate his patient ingenuity and marvel at his perennial courage. At one time surrounded by tropical carnivores, deadly and terrible, and at another time pierced by the storms of arctic winters; a prey to diseases he could not cure, and bewildered by the unseen forces that encompassed him; wandering through every form of error to arrive at the first glimmerings of truth; with no aid and no knowledge from without; witless of the metals that were under his feet, of the wealth of agriculture always in his reach; it was with a weapon of flint that he carved his fortune and smote his adversaries, and raised himself from where he once stood, a little higher than the beasts, to where he stands now, "a little lower "than the angels."

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